

Characteristics of Antarctic Stratospheric Variability During Winter: A Case Study of the 2024 Sudden Stratospheric Warming and Its Surface Impacts

JGR Atmospheres RESEARCH ARTICLE

<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2025JD045089>

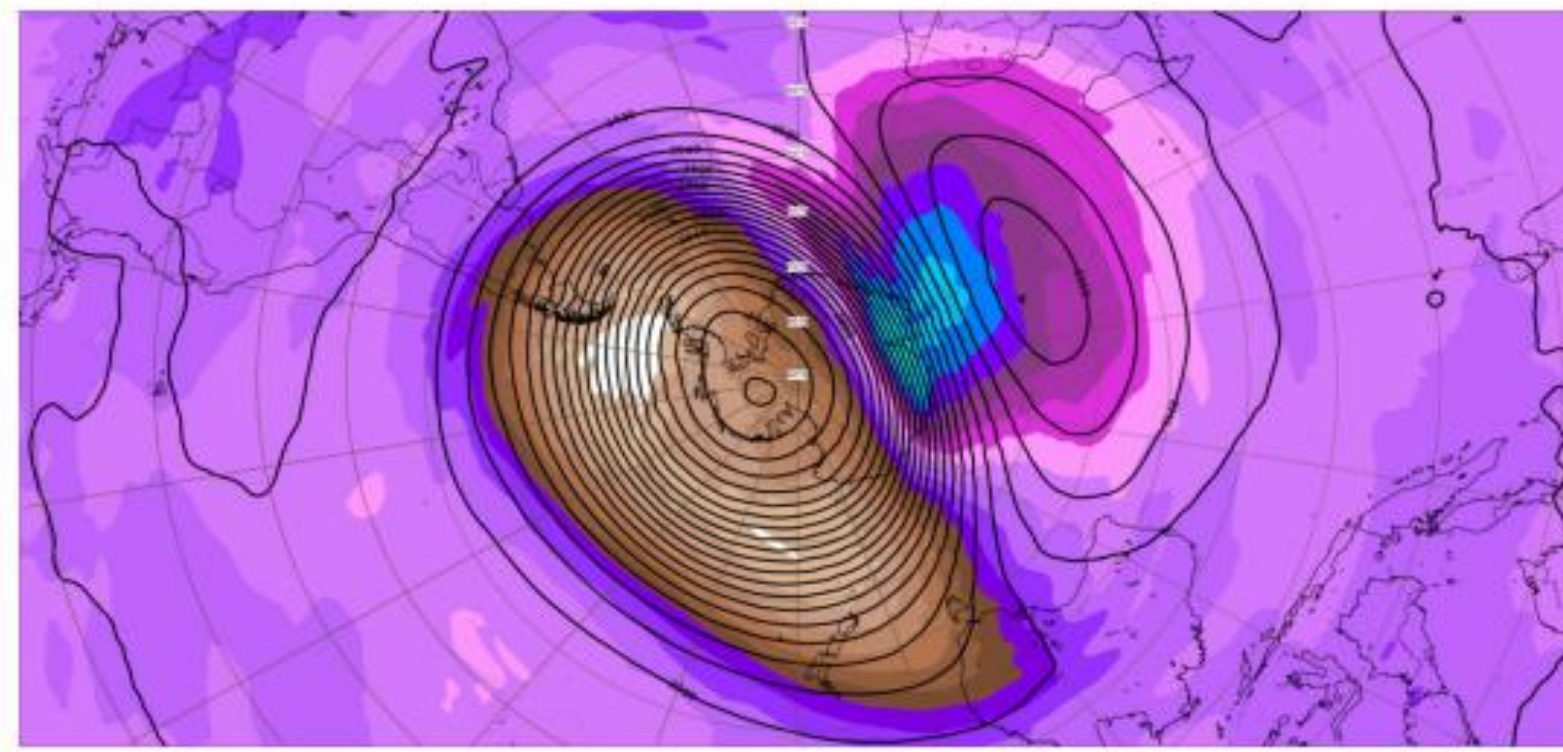
Sudden stratospheric warming event underway – here's what it means for Australian weather

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Ensemble mean for 10 hPa temperature and geopotential

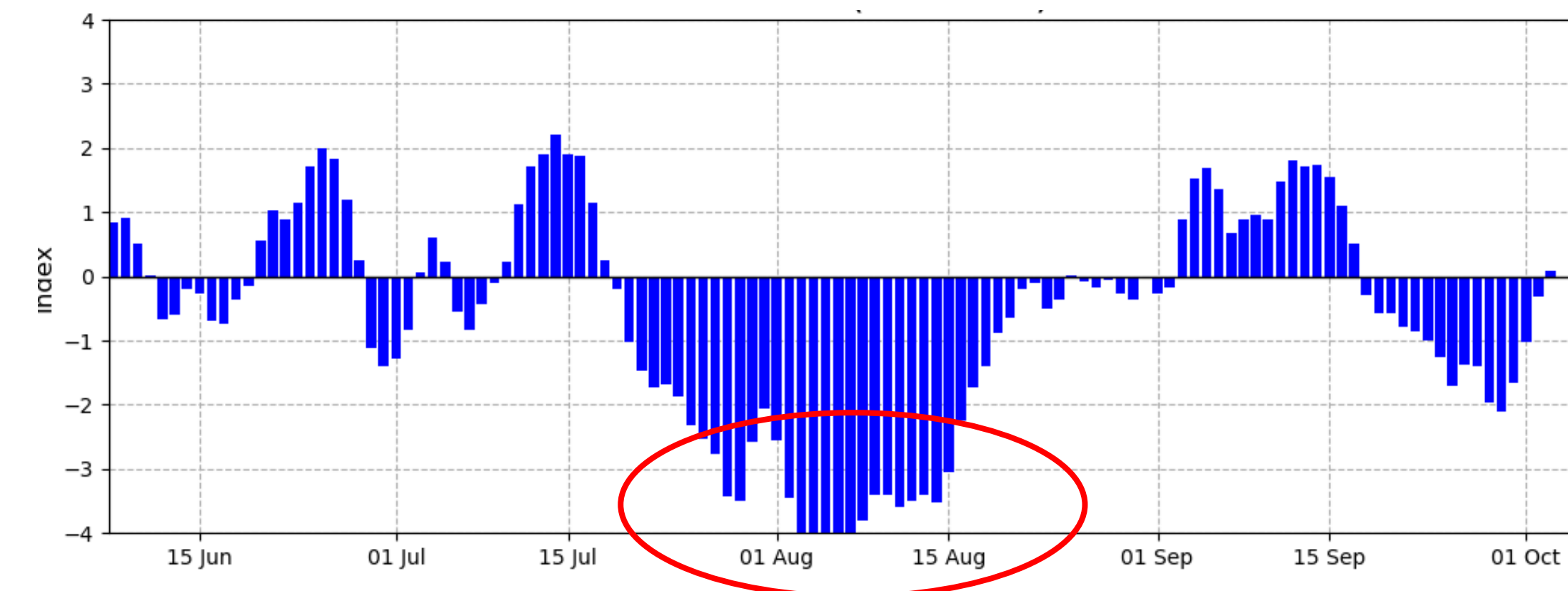
Base time: Thu 11 Jul 2024 12 UTC Valid time: Sun 14 Jul 2024 03 UTC (+630) Area: South Pole



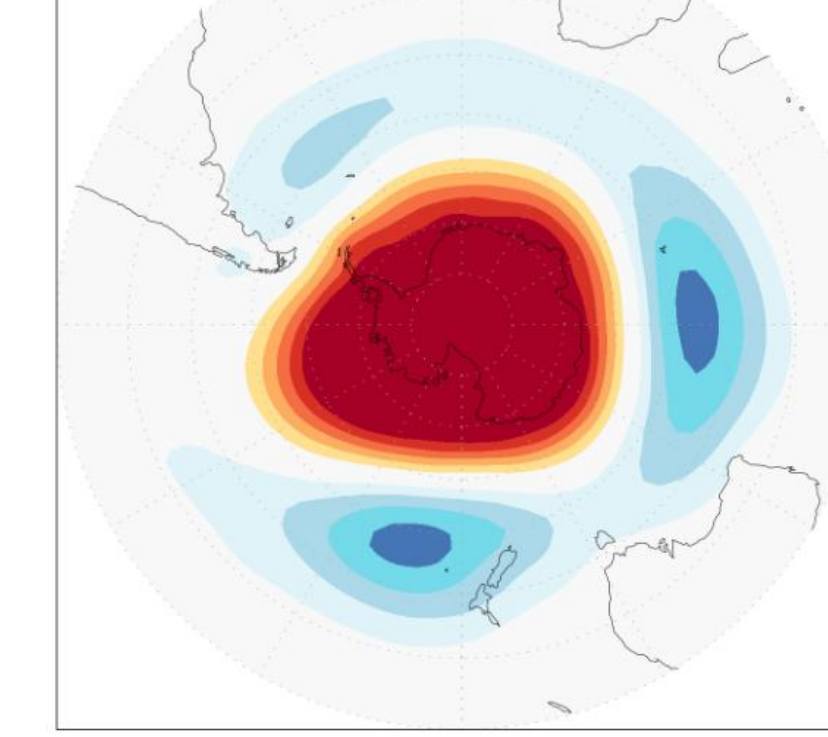
Ensemble mean for 10 hPa temperature (°C)

Base time: Thu 11 Jul 2024 12 UTC Valid time: Sun 14 Jul 2024 03 UTC (+630) Area: South Pole

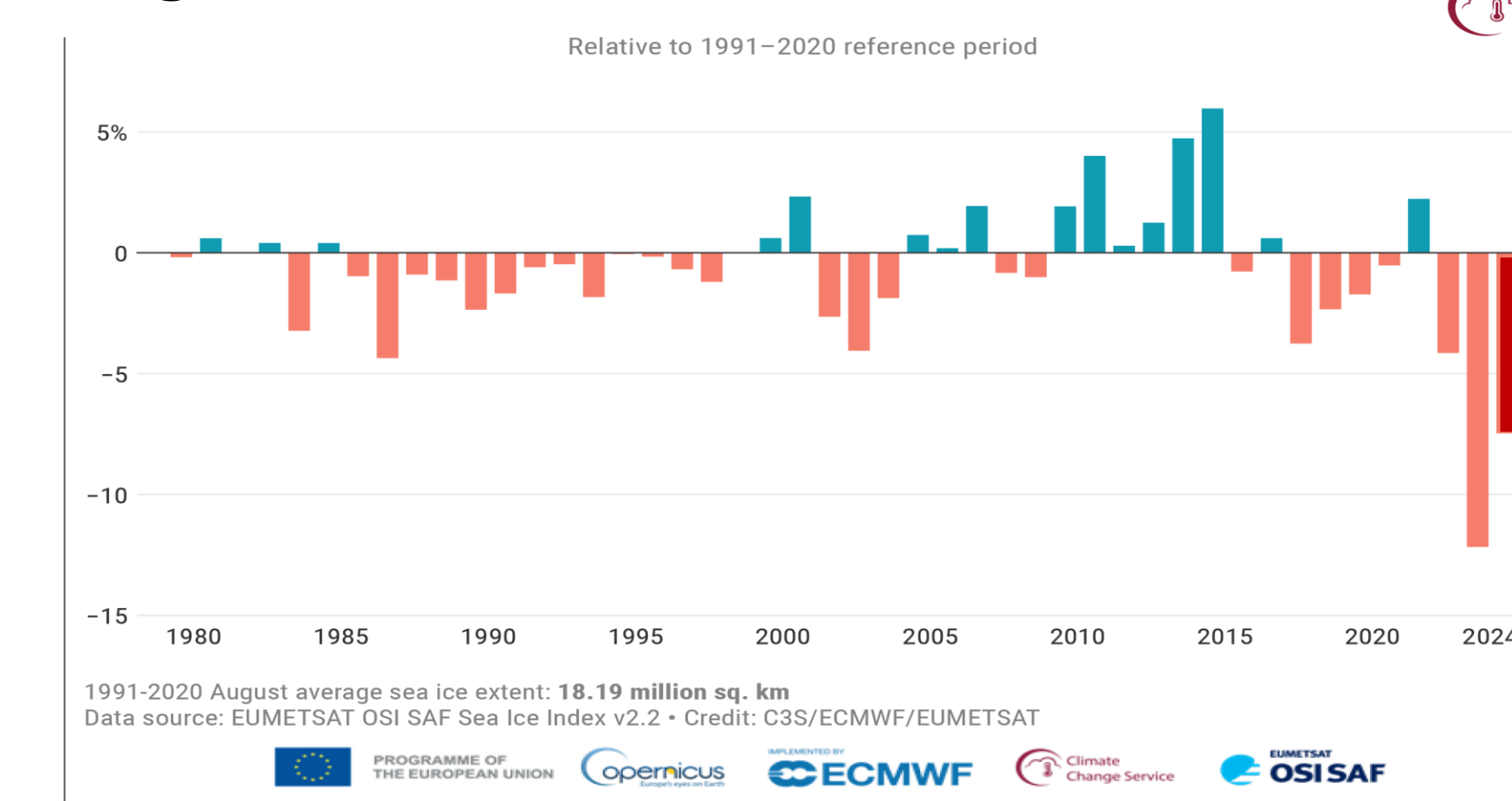
Southern Annular Mode (SAM) Index in June-September 2024



Negative phase of SAM
(mean sea level pressure)

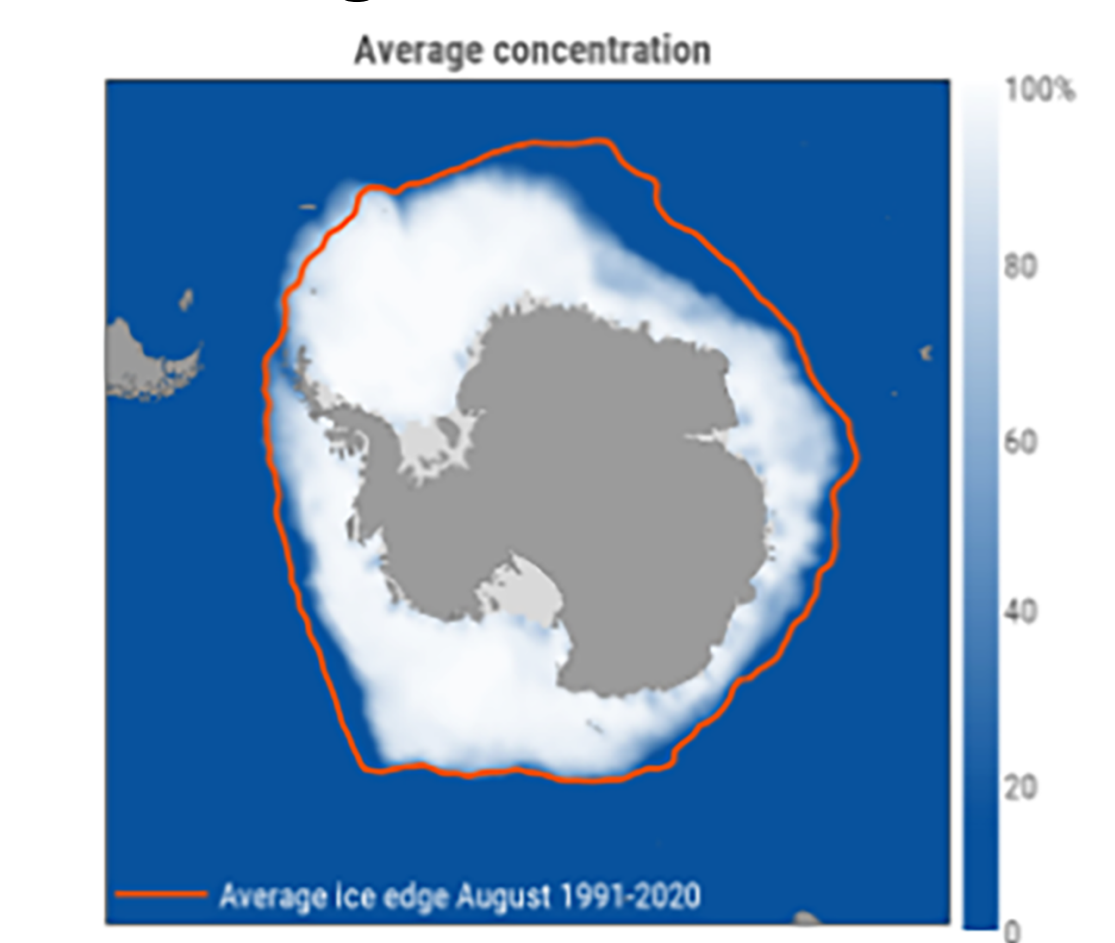


August Antarctic sea ice extent anomalies



1991-2020 August average sea ice extent: 18.19 million sq. km
Data source: EUMETSAT OSI SAF Sea Ice Index v2.2 - Credit: CSIRO/ECMWF/EUMETSAT

2024 August sea ice extent



- Rare and intense winter-time sudden stratospheric warming occurred in July 2024
- Record strong negative phase of the Southern Annular Mode (SAM) followed in early August
- Antarctic region was extraordinarily warm, and the sea-ice significantly contracted

Research Q&As

Q1. What are the typical features of SH winter stratospheric vortex variability and associated anomalous stratospheric warming?

- The most common anomalies involve **vortex expansion (cooling)** or **contraction (warming)** during winter.
- **Stratospheric wind and temperature anomalies** generally have **limited influence on the lower atmosphere in winter.**

Q2. How unusual was the 2024 mid-winter sudden stratospheric warming (SSW) event?

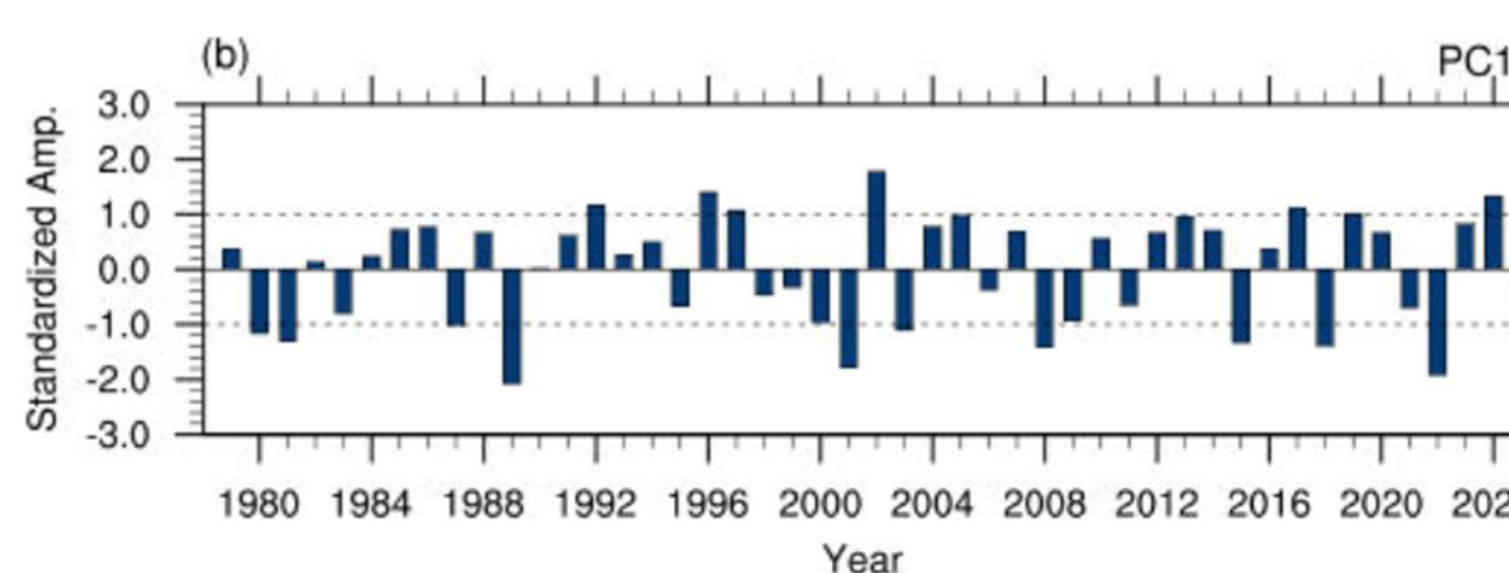
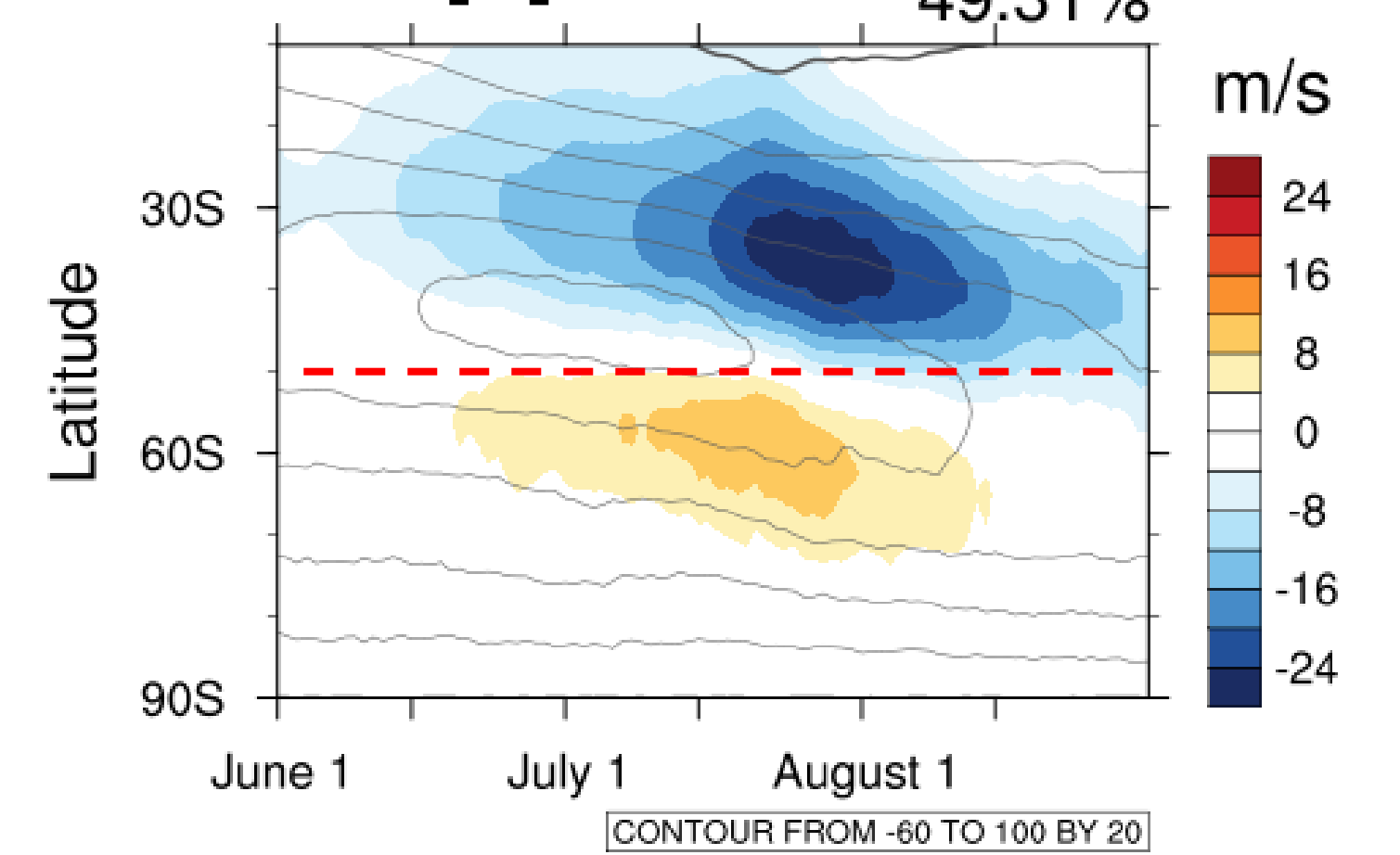
- It was the **earliest SSW on record** since satellite observations began
- **The vortex extraordinarily contracted** toward the South Pole, leading to an **unusual downward influence on the surface, culminating in a record-breaking negative SAM** in early August

Q3. How did the atypical mid-winter SSW and the resulting strong negative SAM affect the Antarctic climate?

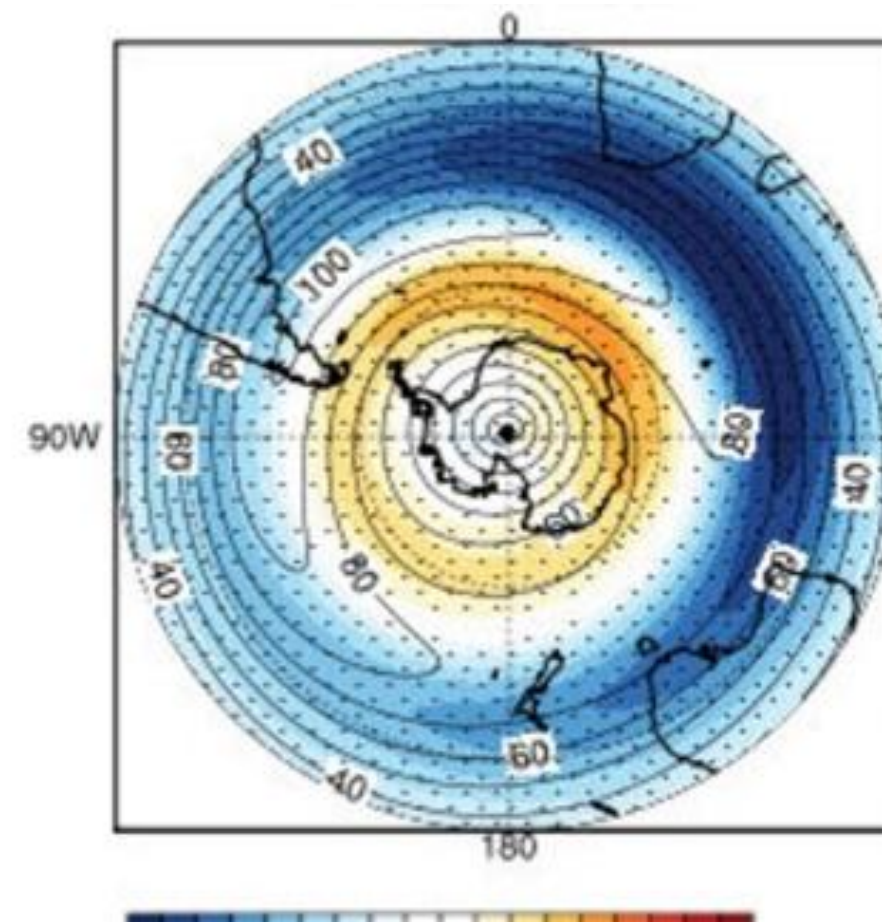
- **Significant surface warming** across the Antarctic continent.
- **Extremely low sea-ice** along the eastern Antarctic coast and over the Amundsen Sea region

Typical Features

EOF1 of [U] at 1 hPa 49.31%

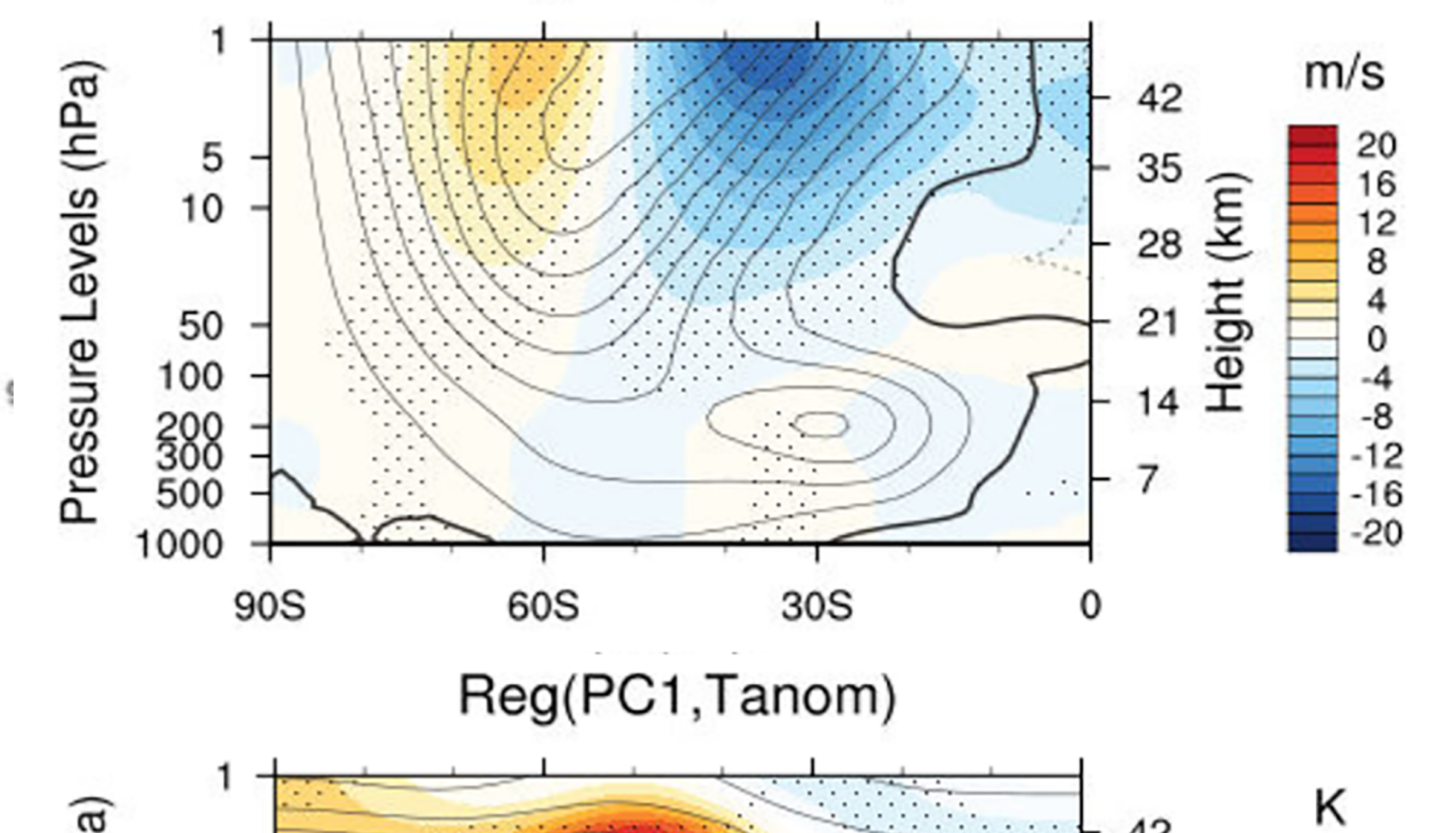


Reg(PC1,U1hPa)

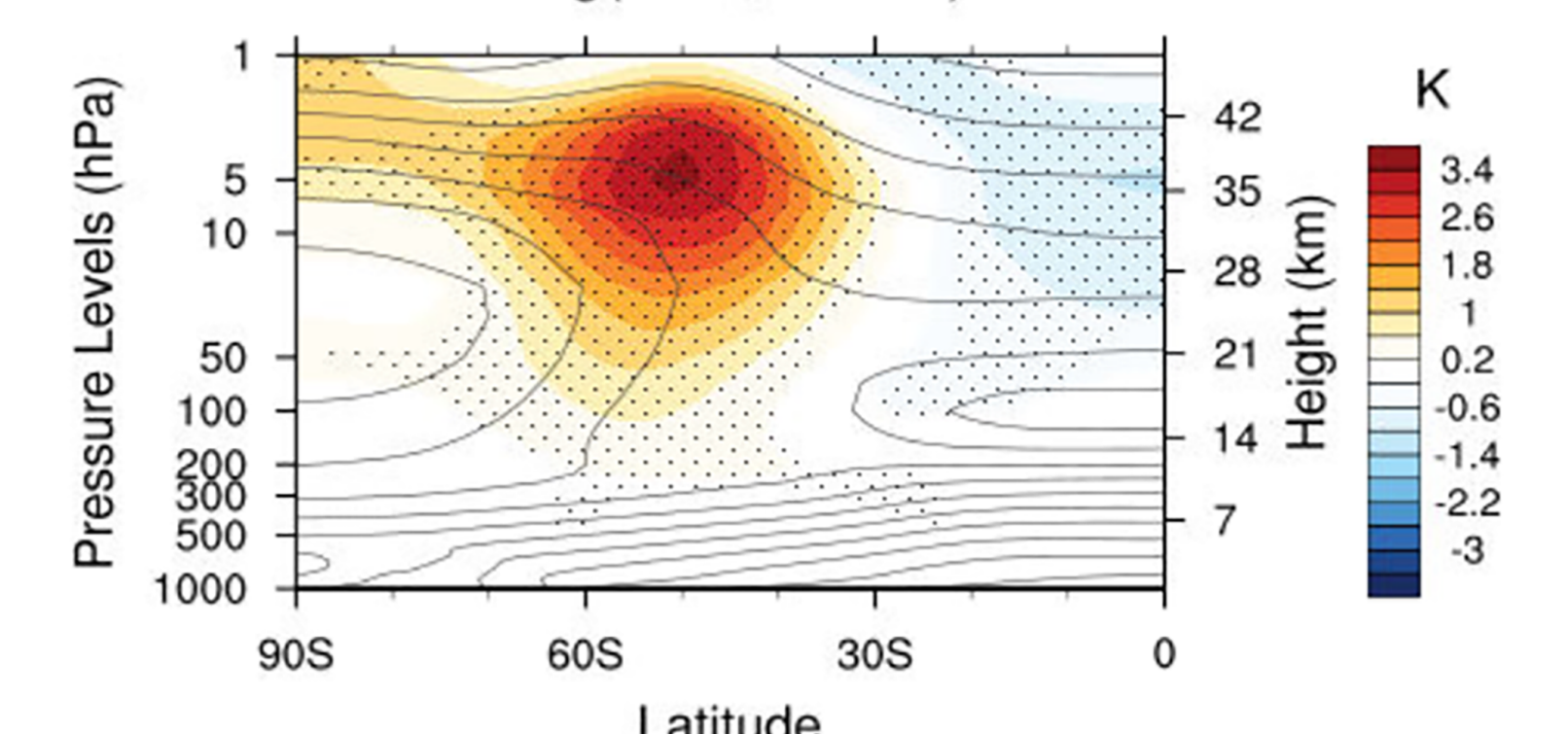


From ERA5 & ERA5.1

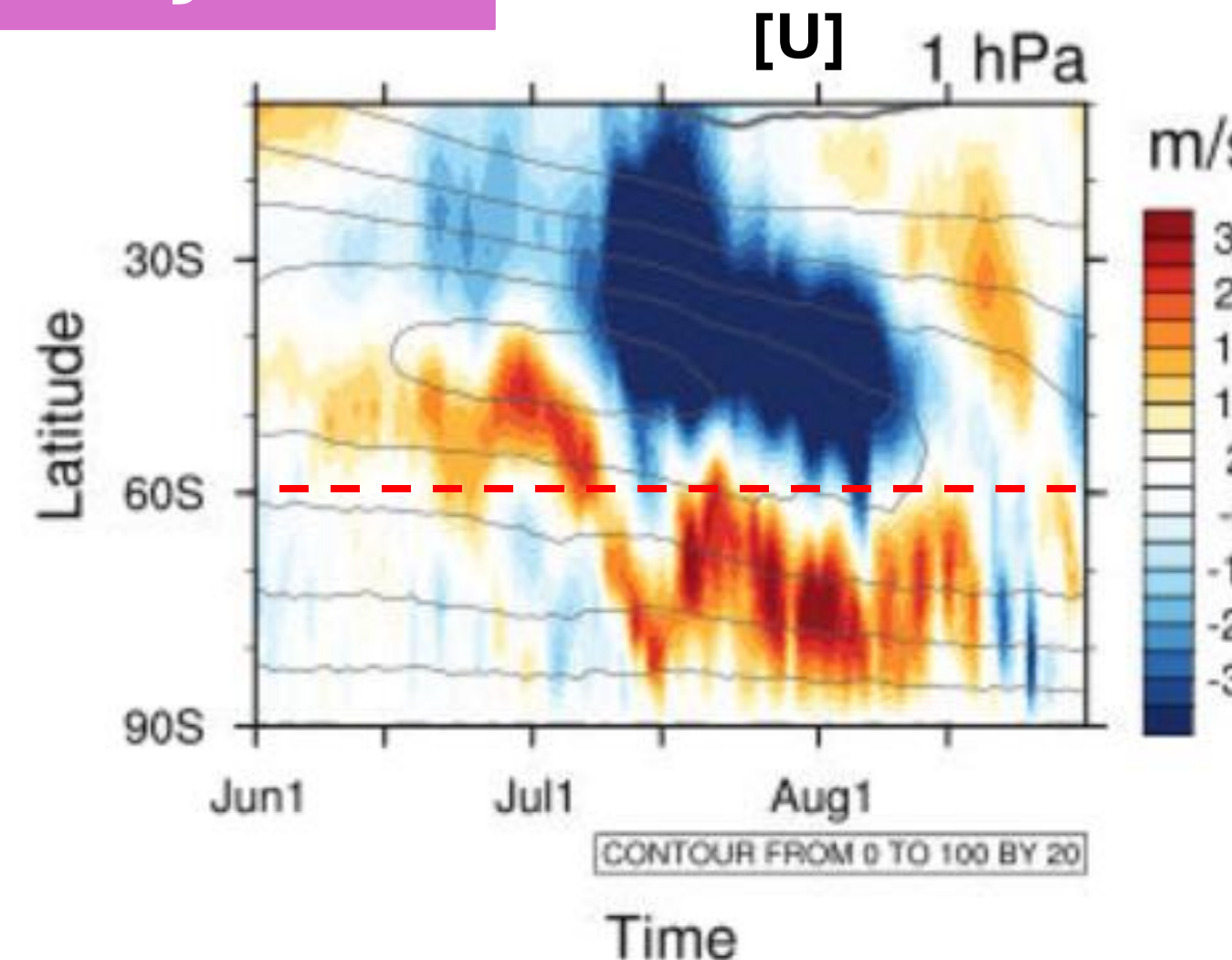
Reg(PC1,Uanom)



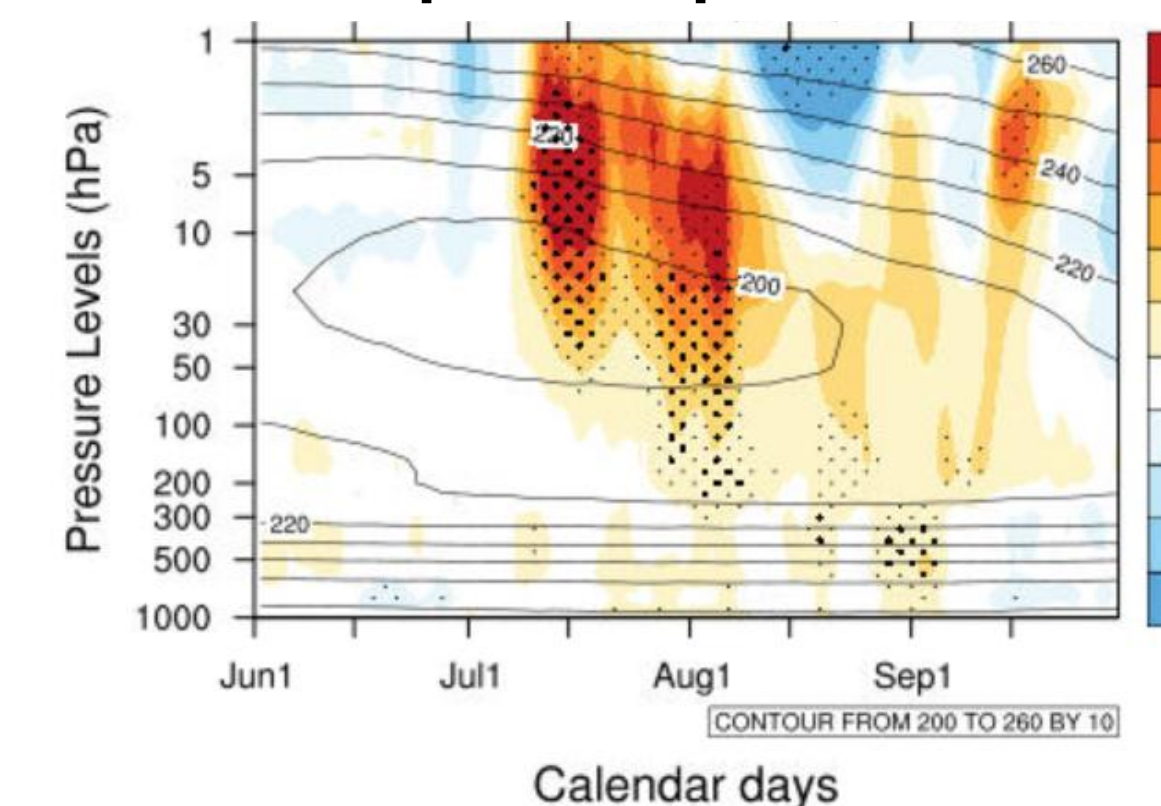
Reg(PC1,Tanom)



July 2024



Antarctic polar cap T anomalies



1-7 August 2024

2-m T anomaly

