# Historical Context of a Recent Warming Event over Wilkes Land, Antarctica from Numerical Analyses

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GMAO
Global Modeling & Assimilation Office



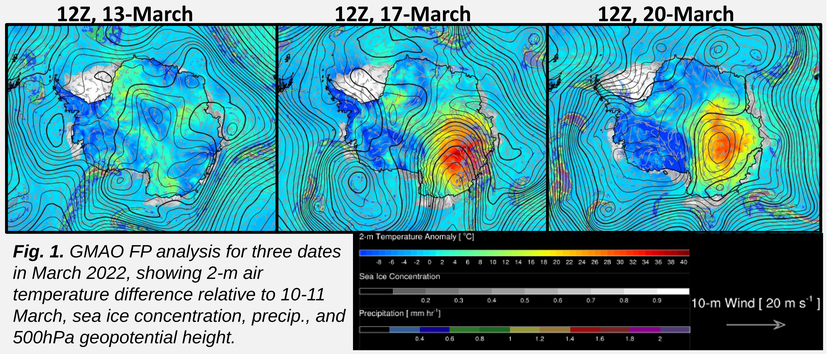


***Fig. 1.*** *GMAO FP analysis for three dates in March 2022, showing 2-m air temperature difference relative to 10-11 March, sea ice concentration, precip., and 500hPa geopotential height.*

## Introduction

Recent melt events over polar ice sheets are of interest for identifying regions of vulnerability in a warming climate. On 11-March 2022 a ridging pattern formed in the jet stream near Enderby Land, Antarctica and progressed eastward. The ridge deepened markedly into a classic omega-shaped blocking pattern (Fig. 1), extending into the plateau by 14-March. The blocking pattern is remarkable for the circulation strength – which forced warm air and moisture into the high interior of the continent, its poleward extent, and its persistence. Here, we use GMAO FP, MERRA-2 analyses, conventional observations, and AIRS/Aqua L3 data to characterize the event. We wish to examine,

- How unusual was the event relative to available analysis records
- What were the effects of the event on surface mass balance (SMB)?
- Is there a relation to general circulation trends that led to this event?

Below (Fig. 2) shows a time series of station temperatures. Coastal stations remained above freezing for about two days. Plateau values remained well above average until 23-March.

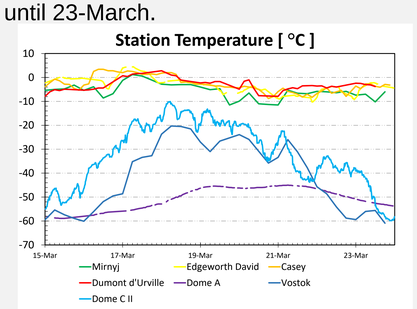


***Fig. 2.*** *Time series of Antarctic station temperatures during March 2022, in °C.*

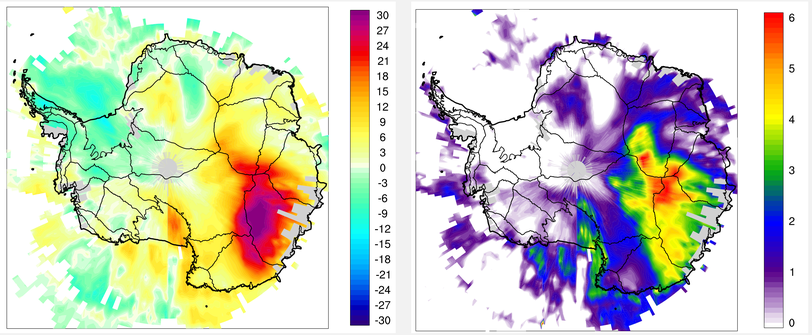

***Fig. 3.*** *Left: skin temperature anomaly from AIRS/Aqua L3 for 17-March 2022, relative to 2003-2021 average. Right: the sigma-departure from the 2003-2021 average.*

## Surface Temperature

Daily fields from AIRS roughly correspond with available station data in showing the largest anomalies on 17-March, which exceed 30°C and are centered over the Totten Basin. The data roughly correspond with reanalyses in suggesting a six- σ departure from mean conditions.

## Surface Mass Balance

MERRA-2 suggest a 9-day event accumulated East Antarctic SMB of 99 GT – about 2.7 times the 1980-2021 average for the period – with 30 GT for 17 March alone. The daily accumulated *P−E* for 17-March ranks first in the 43-yr MERRA-2 record, with 16-March ranking second. The daily amount of liquid precipitation for East Antarctica also ranked first for any date outside of January, although rain amounted to only 0.4 percent of the event's total accumulation.

Despite warm temperatures and record rainfall, MERRA-2 suggests a negligible amount of runoff associated with the event. In the short-term, the event was a significant mass-gain for the ice sheet.

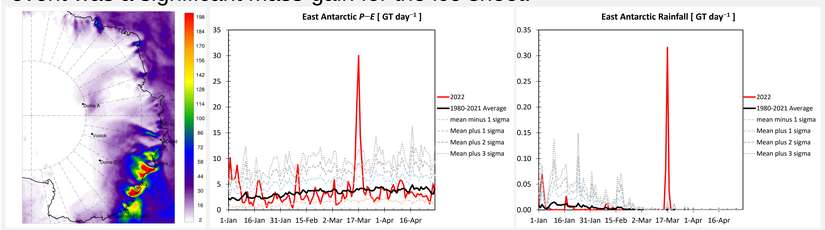


***Fig. 4.*** *Left: total precipitation from FP for 15-23 March, in mm w.e. Center: time series of daily East Antarctic P-E from MERRA-2, in GT. Right: time series of daily East Antarctic rainfall from MERRA-2, in GT.*

## Blocking in the Southern Hemisphere

Various methods have been used to explore atmospheric blocking patterns, and blocking trends. During the event, 400 hPa geopotential heights over the ice sheet are found to denote a 4.5- σ anomaly based on the MERRA-2 record. Here, we identify blocking as a sustained (4-day) reversal in the meridional geopotential height gradient. The method is employed for mid-latitudes 35°S - 75°S. The 400 hPa level is used to minimize interaction with the ice sheet surface. A gradient reversal will detect omega and rex blocking patterns, but not an encroaching sub-tropical high, or other configurations.

As compared to the Northern Hemisphere, Southern Hemisphere blocking is infrequent. Mean blocking patterns for the Southern Hemisphere are shown in Fig. 5. The New Zealand sector has been identified in previous studies as susceptible to blocking, and is highlighted here. At highest latitudes, regions over East Antarctica are identified. Regression trends suggest a general downward trend in the number of high latitude blocking events.

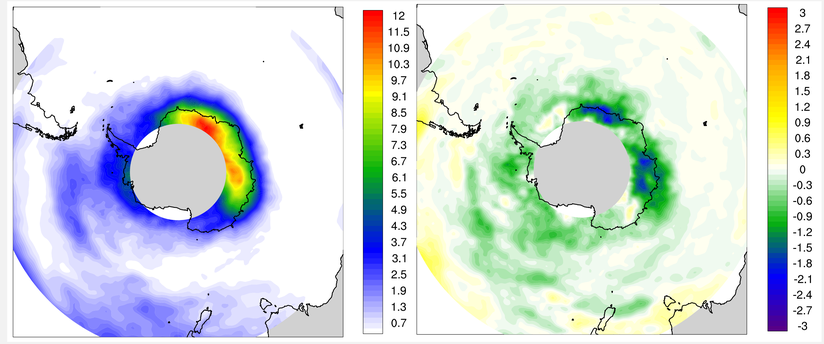

***Fig. 5.*** *Left: map of average count of blocking events per year. Right: trend in blocking events per decade from regression.*

## Summary

- Examination of the full reanalysis time series suggest the extreme rarity of the 15-23 March 2022 event, with surface temperatures corresponding to a six- σ anomaly, and daily East Antarctic precipitation values as largest in the 43-yr record.
- The event was a significant mass-gain for the ice sheet in the short term. It remains to be seen if resulting coastal melt results in instability.
- Analysis suggests the area is susceptible to blocking, but evidence of a trend towards such events is not found.

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