Atmospheric blocking patterns around the Antarctic Peninsula and their influences on temperature and moisture transport

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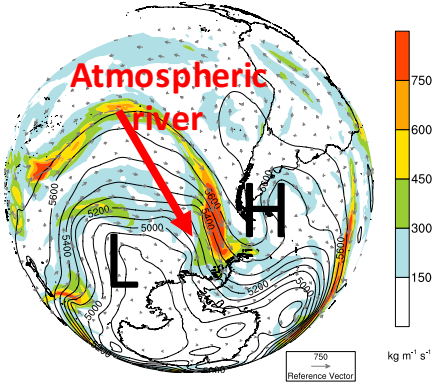
Motivation

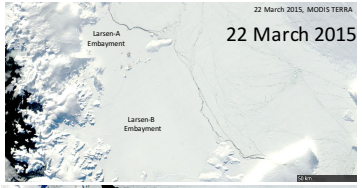
- Antarctic Peninsula (AP) is influenced by baroclinic midlatitude systems, westerlies, and tropical and extratropical quasi-stationary wave trains, which in turn can lead to episodic regional circulation anomalies that are connected to important changes in the Antarctic Peninsula surface climate.
- We thus focus on blocking in latitude belts that include the Antarctic Peninsula, as surface pressure patterns there (particularly in the Amundsen–Bellingshausen Sea and Weddell Sea) have been linked to important sensible weather and cryospheric processes in both Antarctica and South America.
- In addition, blocking events close to Antarctic Peninsula have been linked to extreme temperature and melting events (e.g., March 2015 and February 2020 events in the Antarctic Peninsula).

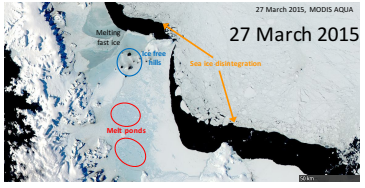
Goals

- To develop a simple index, based on the Greenland BlockingIndex (GBI) used to characterize blocking over Greenland.
- To provide simple metrics to capture extreme blocking around South America and Antarctica.
- To investigate blocking influences on temperature and moisture transport around the Antarctic Peninsula

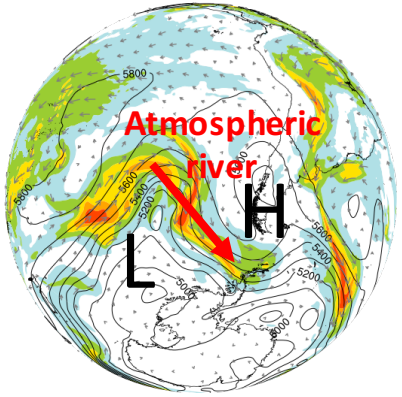
24 March 2015, Antarctic record temperature (17.5C)

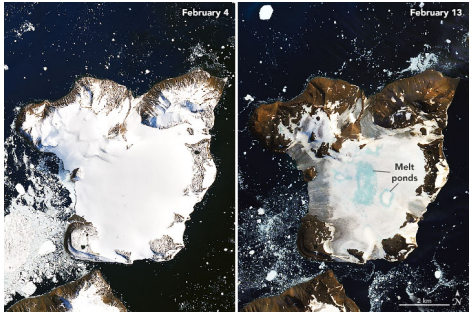




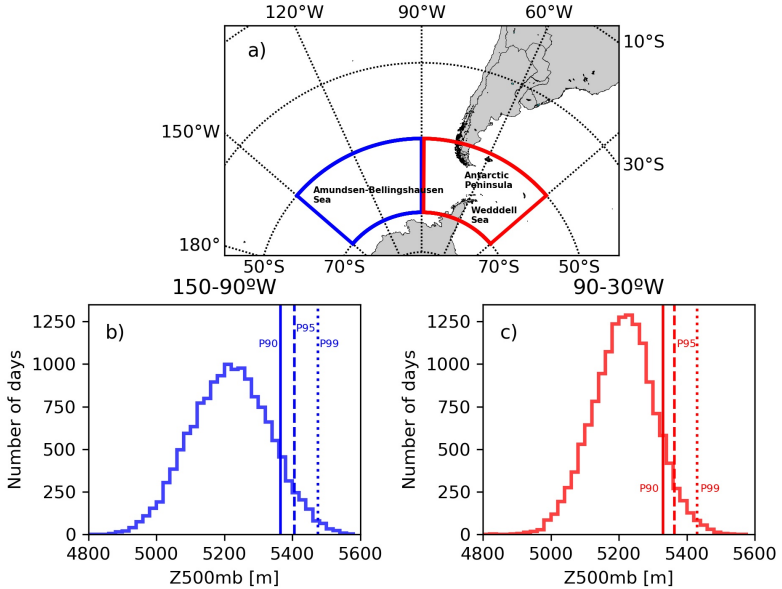


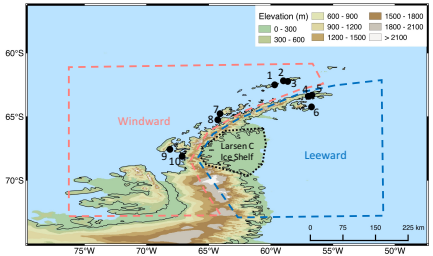
6 February 2020, Antarctic record temperature (18.3C)





Data and methodology





ERA5 Reanalysis:

Blocking indices:

- 500 hPa geopotential heights (Z500) at 0.25º × 0.25º (daily Z500 values at 1200 UTC) between 1979-2020
- Extreme blocking: Mean Z500 over each domain > 90th percentile (P90)
- Very extreme blocking:Mean Z500 over each domain > 95th, 99th percentiles (P95, P99)

Blocking influences:

- Z500 and mean sea level pressure (MSLP) fields (downloaded for 1200 UTC with daily resolution)
- 2m temperature (T2m; downloaded for 1200 UTC with daily resolution)
- Daily integrated vapor transport (IVT) fields by vertically integrating the 6-hr specific humidity and zonal and meridional winds for the whole air column extending from the surface to the top of the atmosphere
- Atmospheric river dataset (Guan and Waliser, 2019)

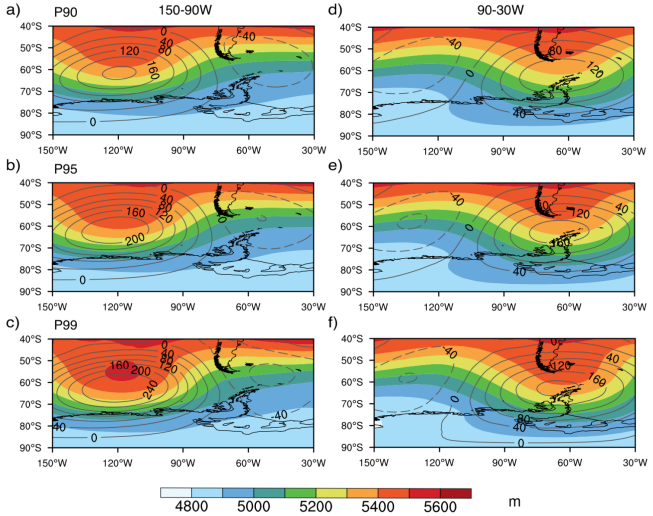
Meteorological observations:

Surface meteorological stations in the Antarctic Peninsula, downloaded from the NOAA Global Summary of the Day database. We analyzed temperature observations from 10 stations located in the central and northern parts of the AP.

Results: Atmospheric blocking patterns and trends

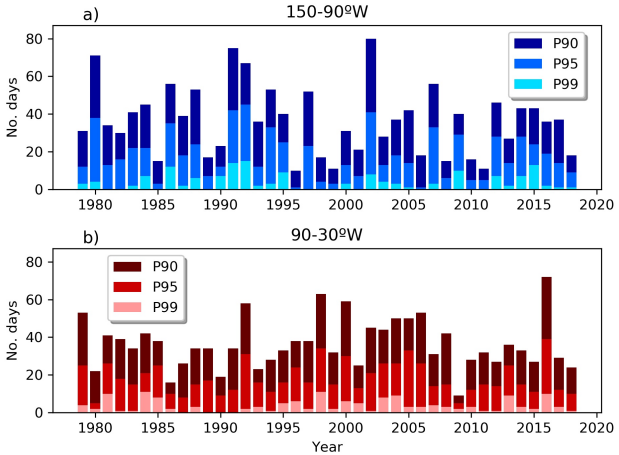
Blocking patterns

Composite mean annual Z500 (shaded), contours are composite mean Z500 height deviations from 1979-2020



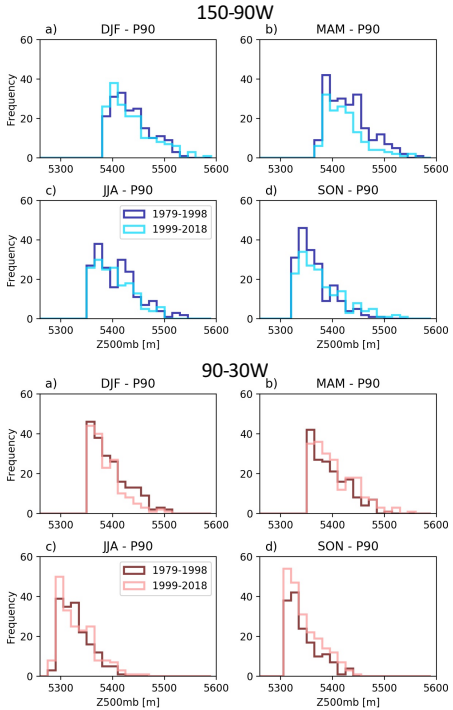
- Synoptic patterns during blocking conditions over the 150-90W domain are associated with a mid-level ridge largely covering the blocking domain, whereas the northeast AP and southern South America are characterized by mid-troposphere lows.
- Extreme blocking conditions over the 90-30W domain feature a mid-level ridge extending from southern South America towards the Drake Passage and the AP.

Interannual variability of P90 blocking days



- No clear trend in the annual frequency of P90 days.

Trend in extreme blocking days



- Number of days with extreme blocking decreased in the 1999-2018 period during all seasons over the 150-90W domain.
- Extreme blocking days tend to increase in the 1999-2018 period in MMA, JJA and SON over the 90-30W domain.

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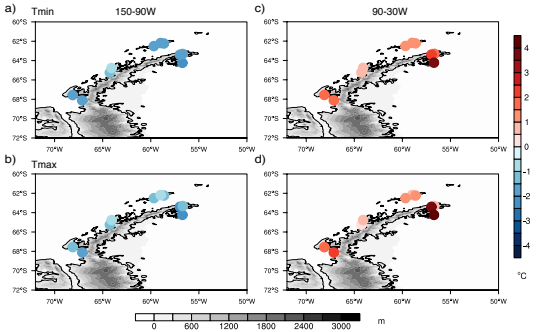
Results: Influences of atmospheric blocking patterns

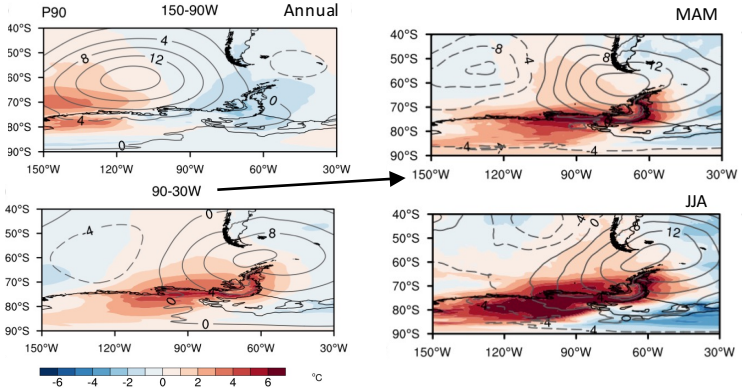
Temperature

Composite observed minimum and maximum 2-m temperature anomalies for P90 blocking days



Colder conditions than the observed climatology in the AP during blocking days over the western domain. On the contrary, mean blocking days over and to the east of the Peninsula yield warmer conditions than the climatology.

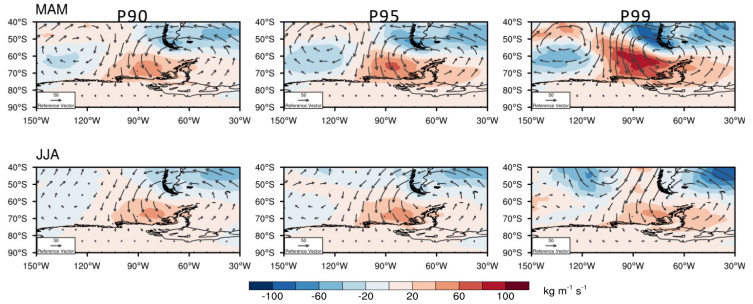
Composite mean ERA5 T2m (shaded) anomalies, contours are composite mean MSLP deviations from 1979-2020



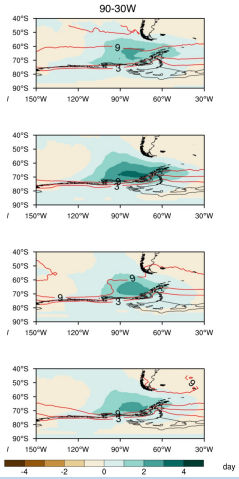
- Similar to the observed pattern, ERA5 also shows colder and warmer conditions during blocking days over the western and eastern domains, respectively.
- In general, P99 days over the 90-30W domain lead to the the largest mean warm anomaly on the leeward side and southwestern Peninsula in JJA and MAM.

Moisture transport and atmospheric rivers (ARs)

Composite mean ERA5 IVT anomalies for blocking days over the 90-30W domain



Seasonal AR frequency deviations from climatology for the P90 blocking days over the 90-30W domain



Circulation anomalies during the 90-30W blocking trigger northerly/northwesterly flow and enhanced moisture transport towards the Amundsen Sea and the AP mostly in the form of ARs.

	P90	P95	P99
DJF	42	50	51
MAM	55	64	90
JJA	52	62	64
SON	59	61	71
ANNUAL	52	58	70

The largest percentages of blocking days coinciding with landfalling ARs are evident in austral autumn on P95 and P99 days.

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Conclusions and outlook

- Blocking days were found to be more frequent in the first half of the period (1979-1998) than the second (1999-2018) in all seasons in the west domain (90-150W), whereas they seem to be more common over the eastern (Peninsula) domain in 1999-2018 for austral winter, spring, and autumn, although these differences were not statistically significant.

- The results presented in this study confirm that blocking patterns around the AP can lead to important anomalies in temperature and moisture transport as well as the frequency of ARs.

- Current work is underway to assess the seasonal differences in blocking influences and physical mechanisms.

More information:

- Marín, J., Bozkurt, D., Barrett, B., 2022. Atmospheric blocking trends and seasonality around the Antarctic Peninsula. Journal of Climate, 35(12), 3803-3818, https://doi.org/10.1175/JCLI-D-21-0323.1.

- Bozkurt, D., Marín, J., Barrett, B., 2022. Temperature and moisture transport during atmospheric blocking patterns around the Antarctic Peninsula. Weather and Climate Extremes, under review.