Does the Antarctic Slope Current control ocean heat transport towards Antarctica?

with Wilton Aguiar, Taimoor Sohail, Ellie Ong,
Paul Spence, Wilma Huneke, Fabio Dias, Matt England

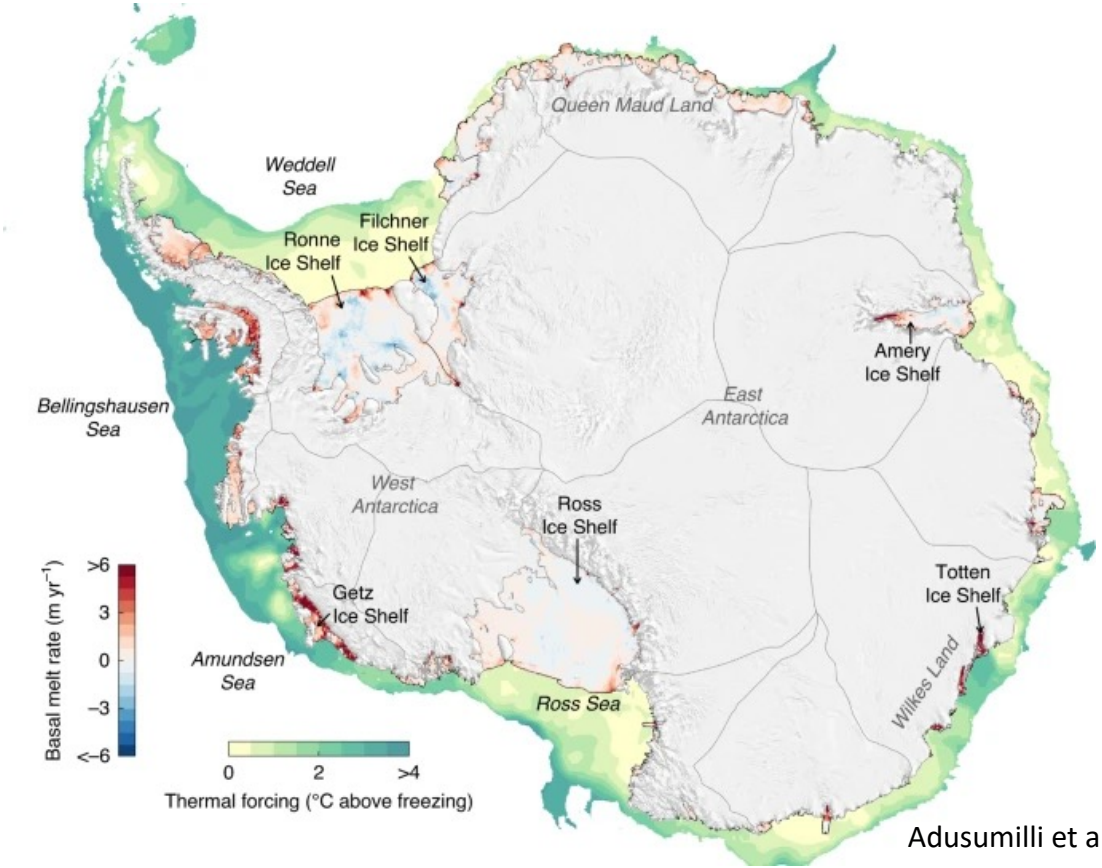






Ocean heat transport controls Antarctic ice shelf melt.

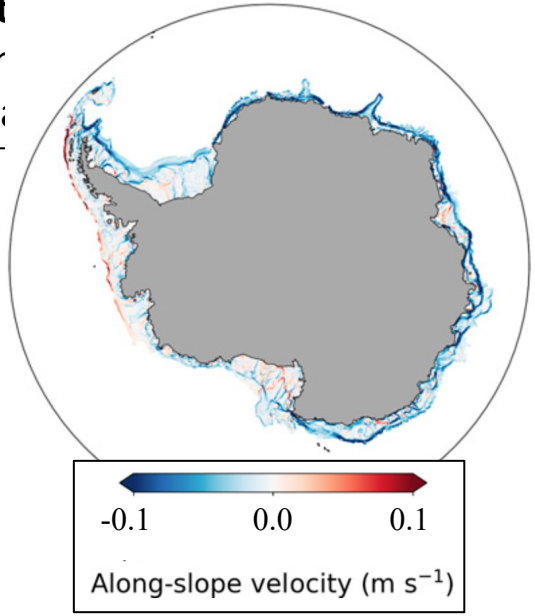
But what controls ocean heat transport?



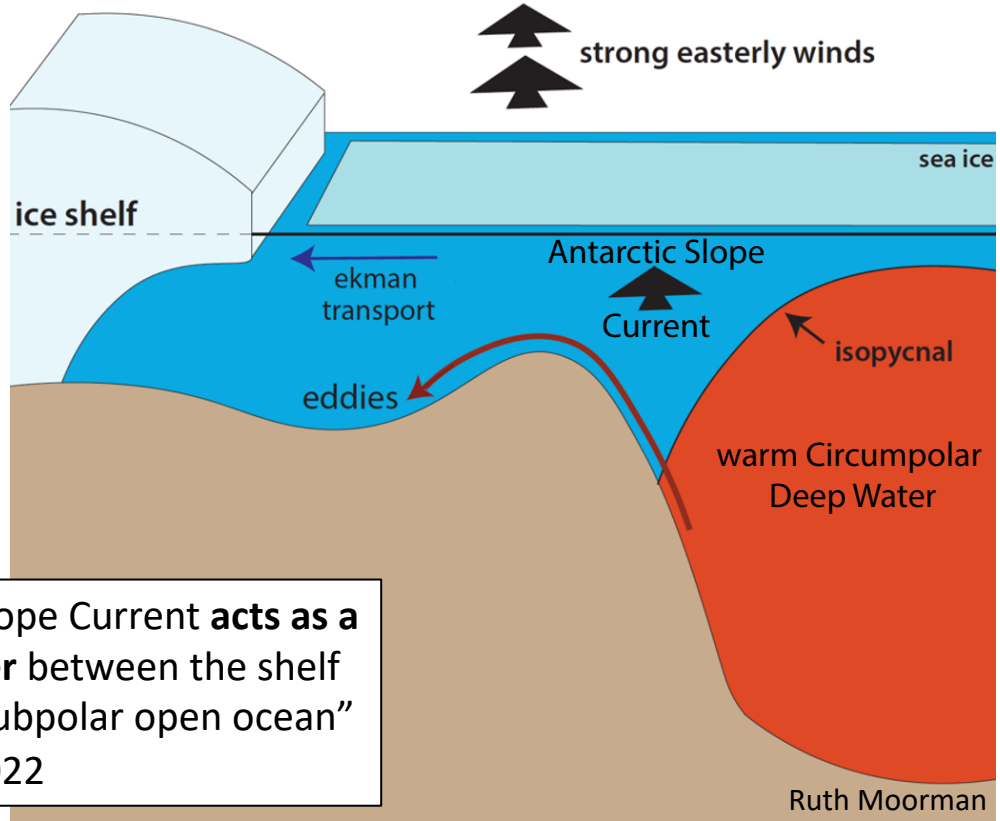
Adusumilli et al. 2020

"The intensity and variability of the Antarctic Slope Current **control the rate at which heat moves across the continental slope** and on to the continental shelf."
Thompson et al. 2018

"The Antarctic Slope Front
const
warm
Stewa



Huneke et al. 2022



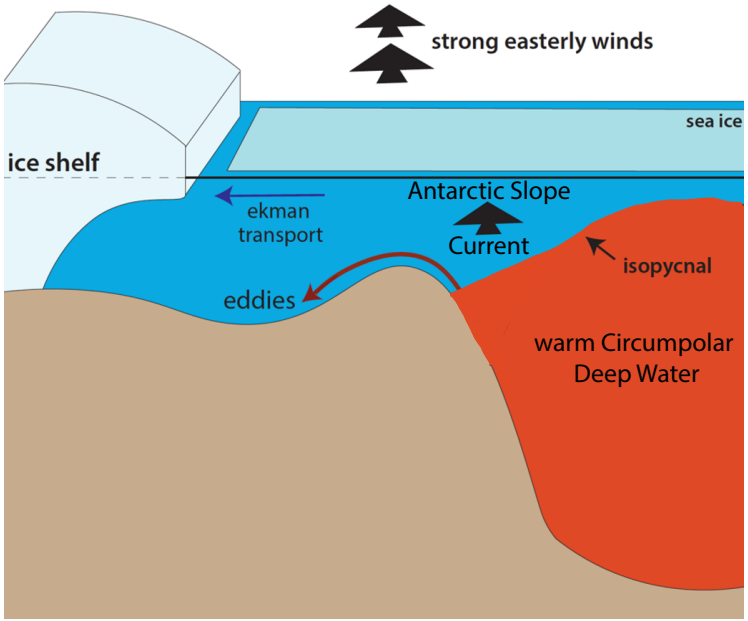
"The Antarctic Slope Current **acts as a dynamical barrier** between the shelf waters and the subpolar open ocean"
Beadling et al. 2022

"It **regulates the exchange of water** across the shelf break"
Pena-Molino et al. 2016

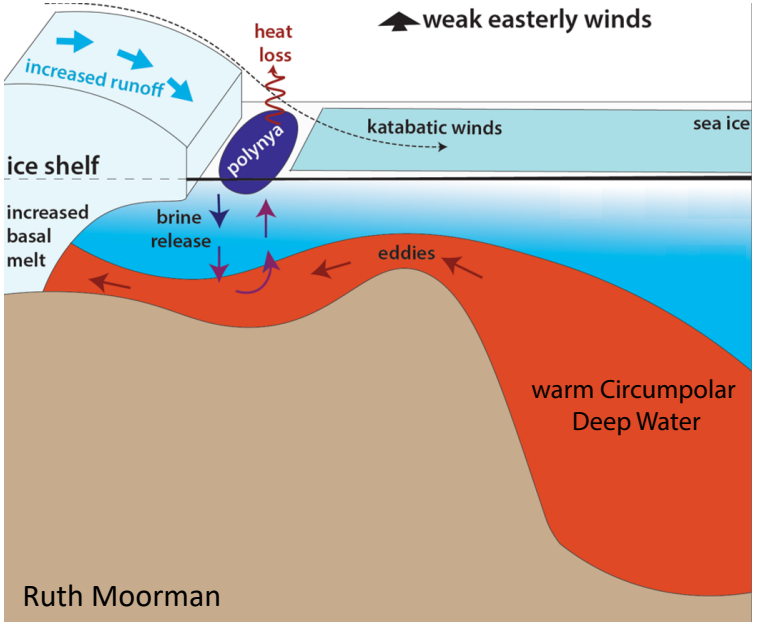
Why would the Antarctic Slope Current control cross-slope heat transport?

1. It acts as a “barrier” – i.e. warm offshore water can’t cross the strong front.
2. Flattened isopycnals -> a) weaker slope current, and b) easier shelf access for warm water.

Fresh shelf regime

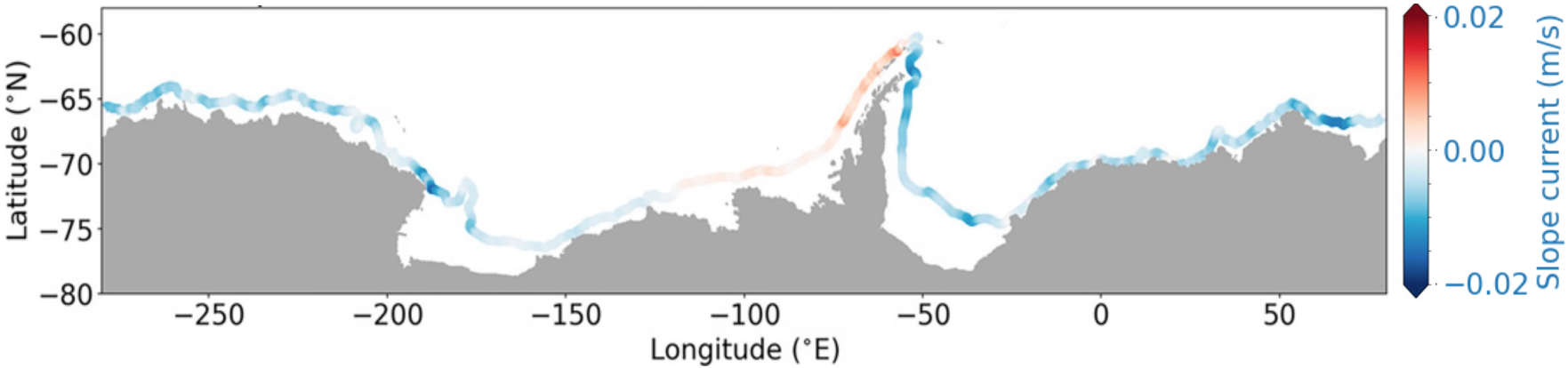


Warm shelf regime



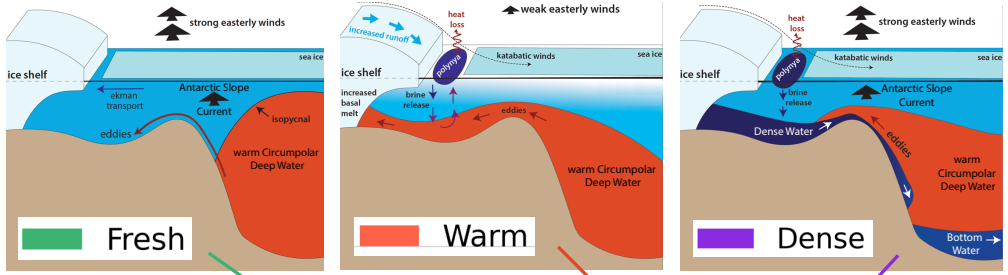
ACCESS-OM2-01 has a good representation of the Antarctic Slope Current (Huneke et al. 2022).

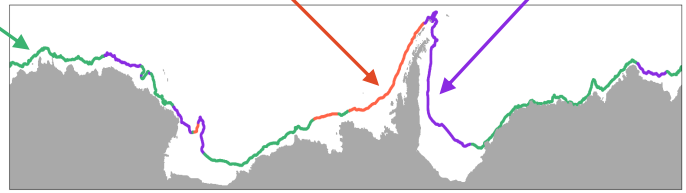
Antarctic Slope Current strength is defined as along-slope velocity on 1000 m isobath.

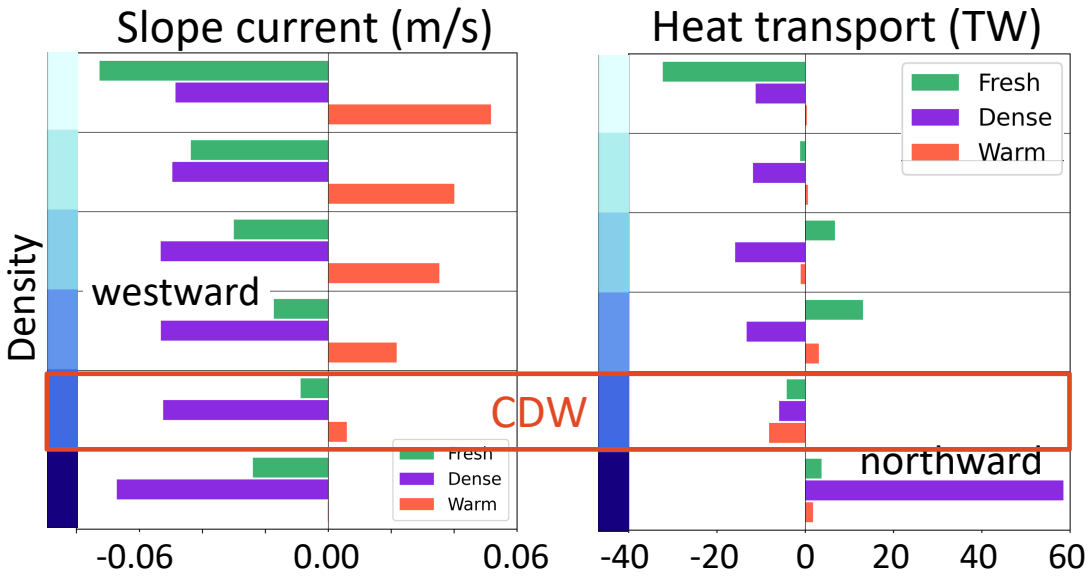


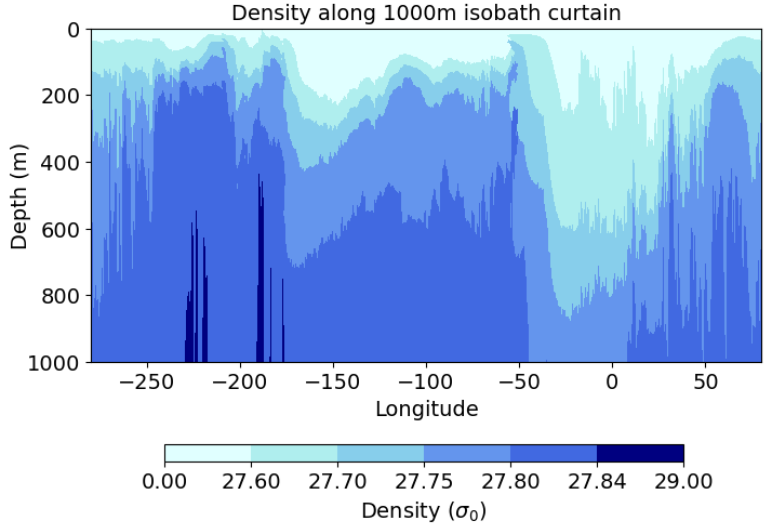
Cross-slope heat transport is computed across the 1000 m isobath.

- defined relative to the freezing point temperature.
- zonal convergence is added to to remove the impact of the slope current crossing the isobath.

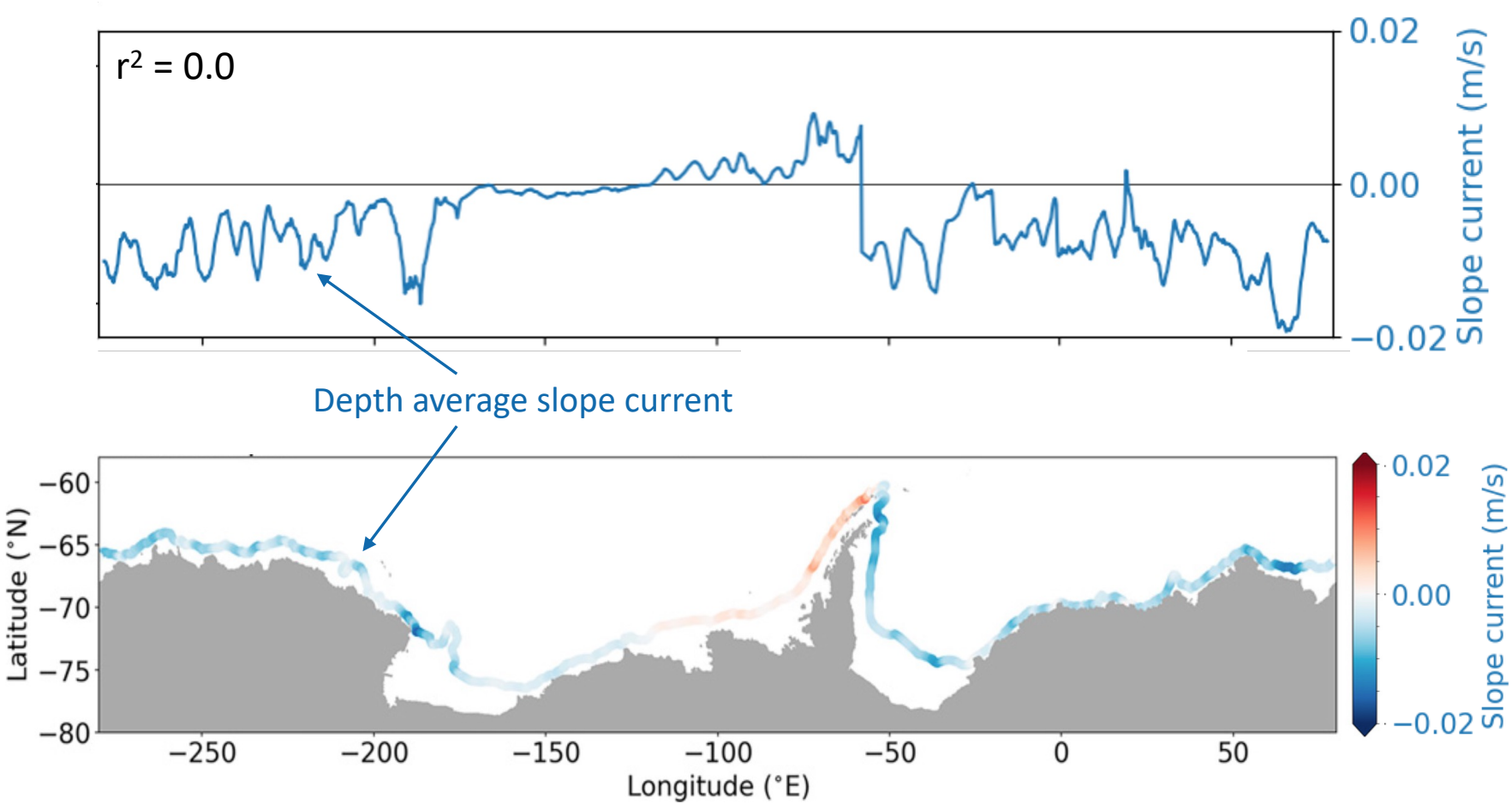

strong easterly winds
sea ice
ice shelf
ekman transport
Antarctic Slope Current
eddies
isopycnal
warm Circumpolar Deep Water
Fresh
heat loss
increased runoff
weak easterly winds
polynya
katabatic winds
increased basal melt
brine release
Warm
Dense Water
Bottom Water

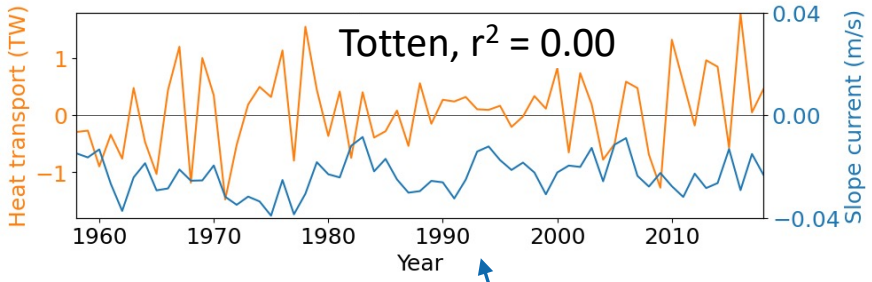



Slope current (m/s)
Heat transport (TW)
Density
westward
CDW
northward
Fresh
Dense
Warm
-0.06
0.00
0.06
-40
-20
0
20
40
60

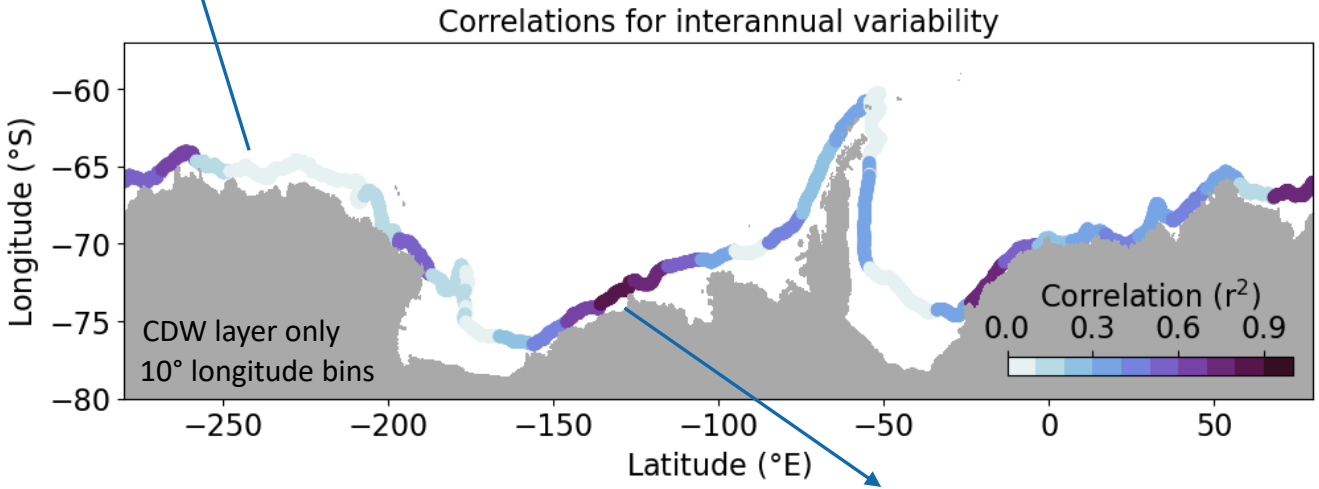

Density along 1000m isobath curtain
Depth (m)
0
200
400
600
800
1000
−250
−200
−150
−100
−50
0
50
Longitude
0.00
27.60
27.70
27.75
27.80
27.84
29.00
Density (σ_0)

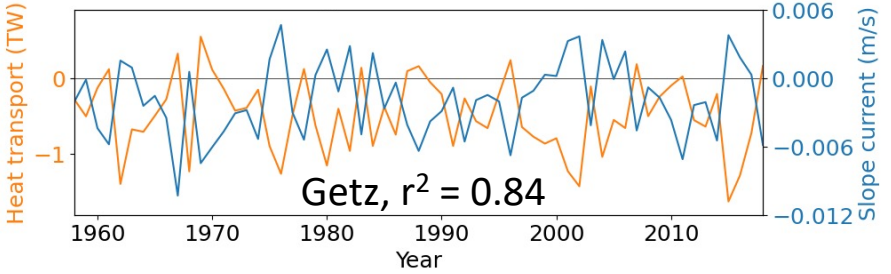
No spatial correlation between time mean Antarctic Slope Current and heat transport.

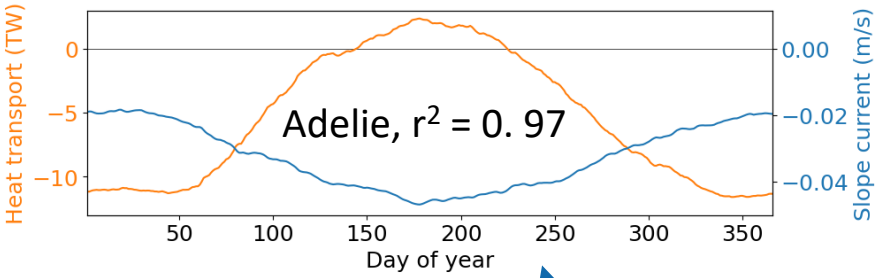


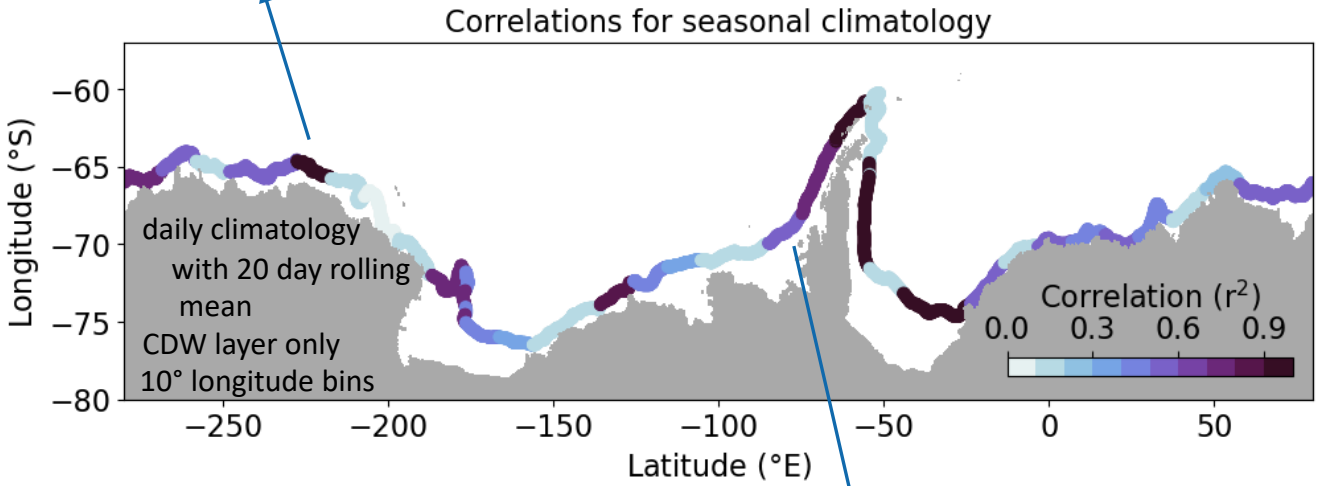


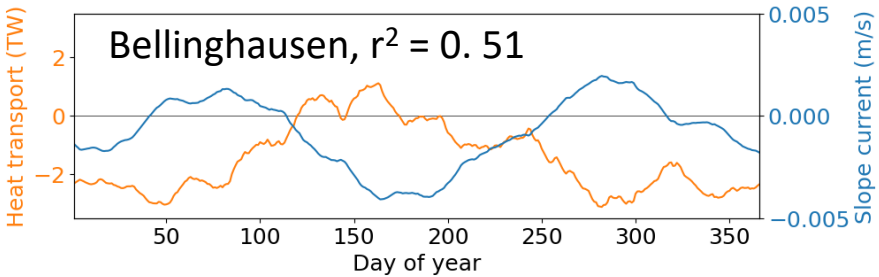
ctic Slope Current impact heat transport?

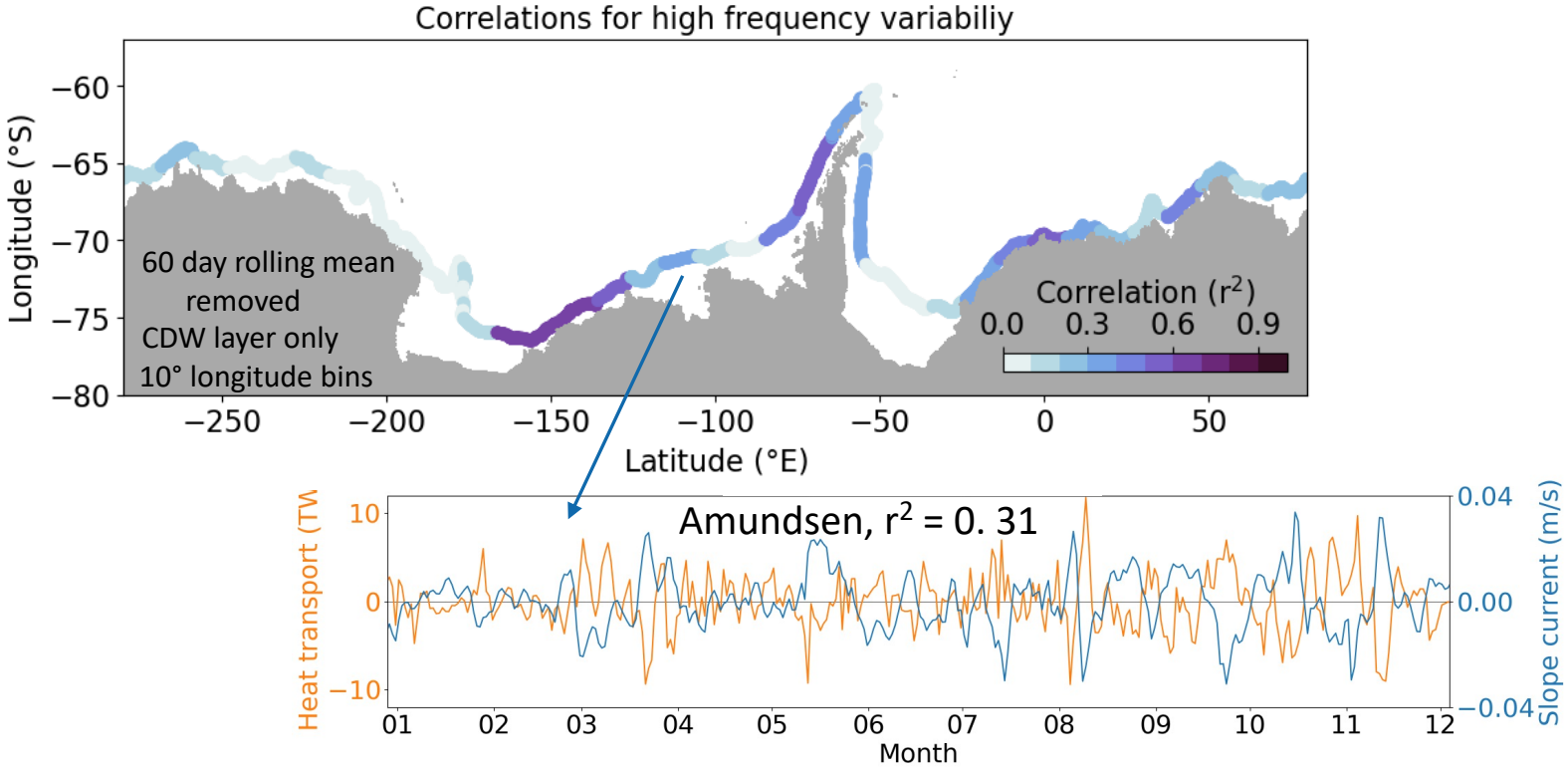




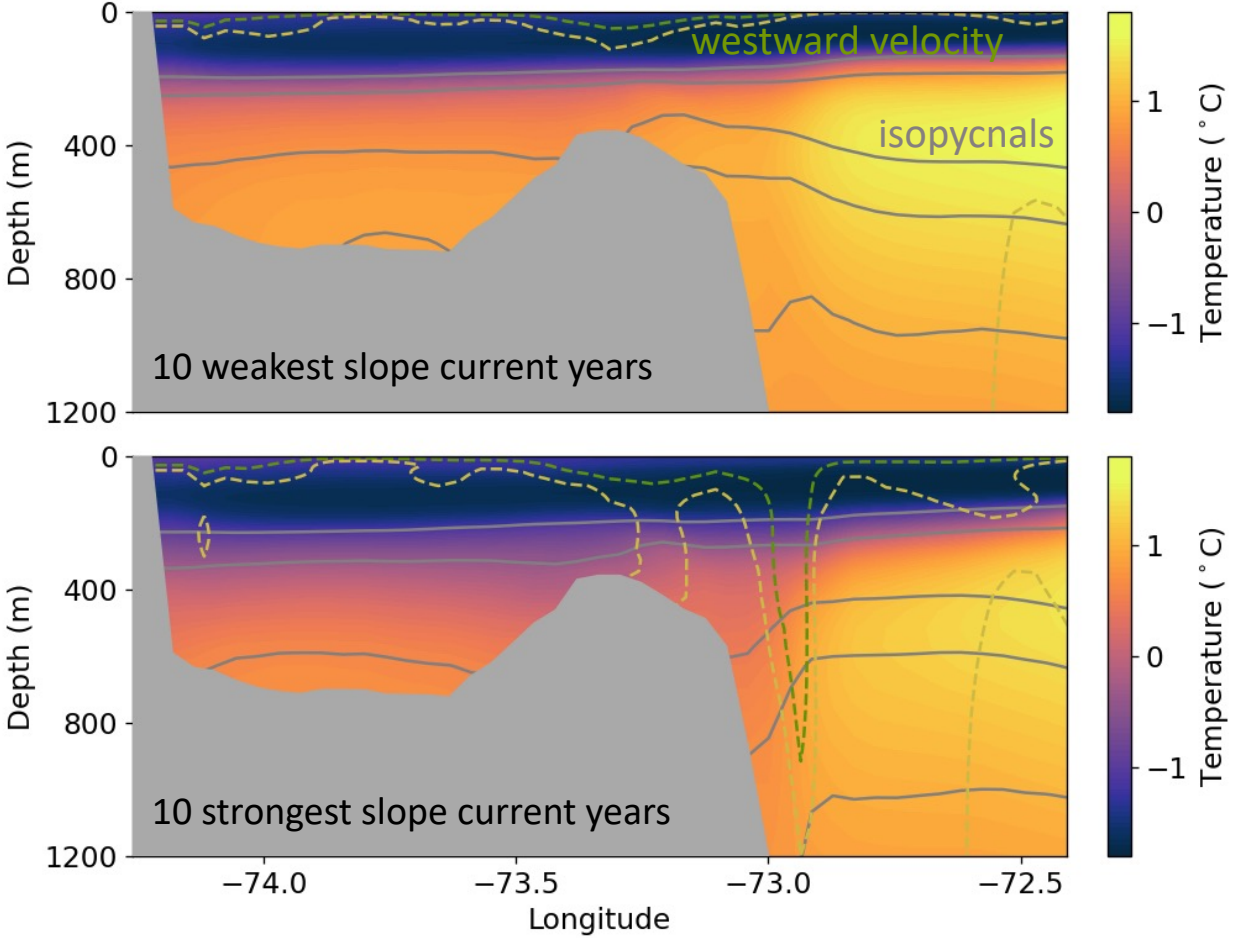

Heat transport (TW)
Slope current (m/s)
Adelie, r² = 0. 97
Day of year


Correlations for seasonal climatology
Longitude (°S)
Latitude (°E)
daily climatology
with 20 day rolling
mean
CDW layer only
10° longitude bins
Correlation (r²)
0.0 0.3 0.6 0.9


Heat transport (TW)
Slope current (m/s)
Bellinghausen, r² = 0. 51
Day of year

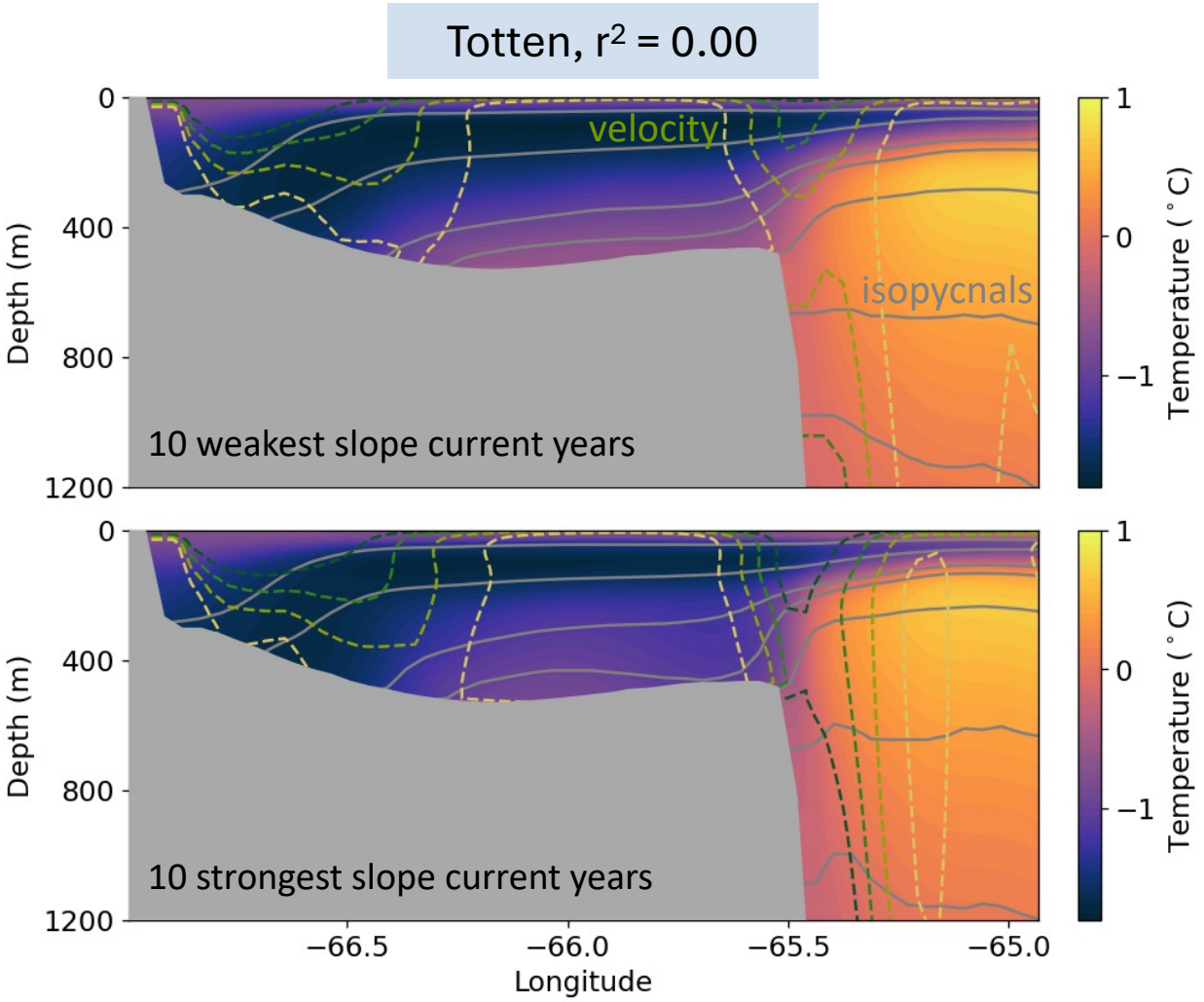

Correlations for high frequency variabiliy
Longitude (°S)
−60
−65
−70
−75
−80
60 day rolling mean removed
CDW layer only
10° longitude bins
Correlation (r²)
0.0 0.3 0.6 0.9
−250 −200 −150 −100 −50 0 50
Latitude (°E)
Amundsen, r² = 0. 31
Heat transport (TW
10
0
−10
0.04
0.00
−0.04
Slope current (m/s)
01 02 03 04 05 06 07 08 09 10 11 12
Month

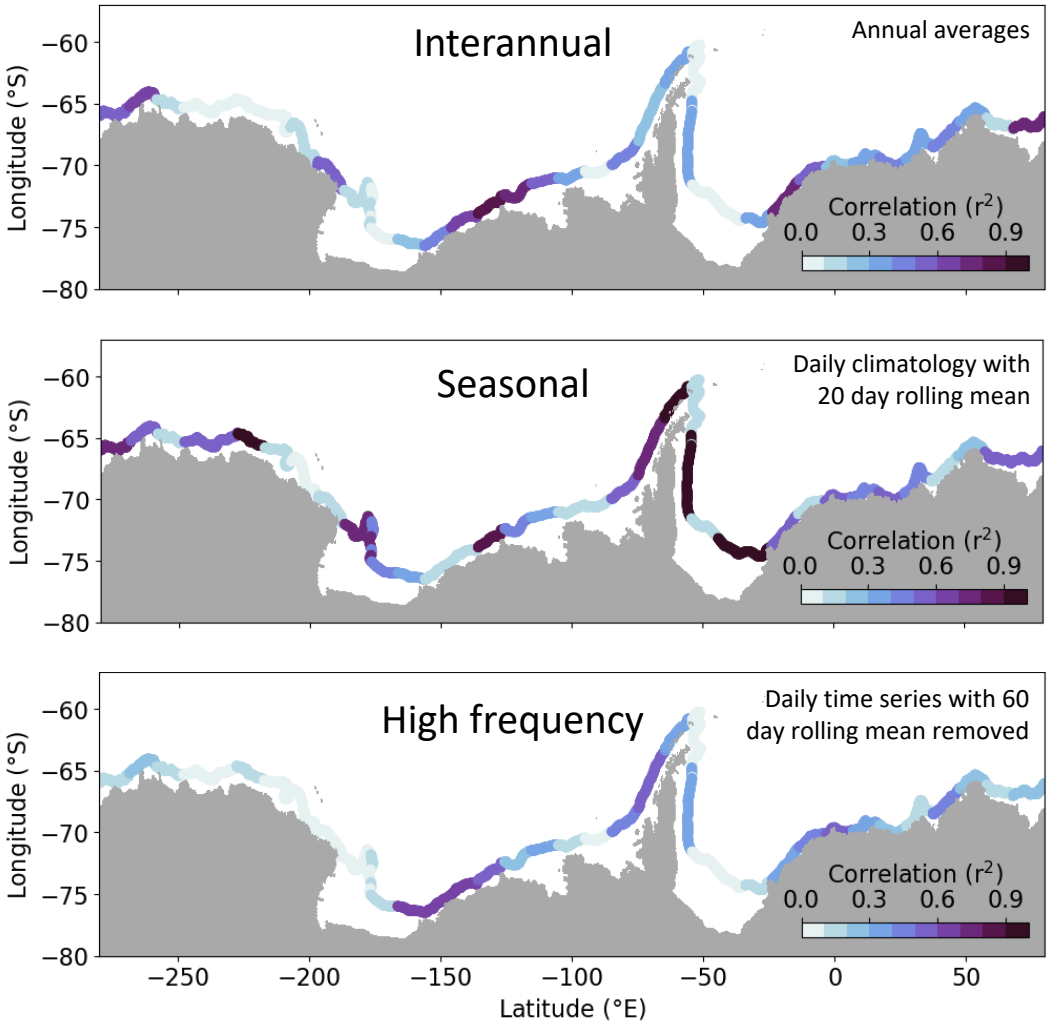
Getz, $r^2 = 0.84$



Does the Antarctic Slope Current actually control cross-slope heat transport?

Or do both change concurrently in response to external forcing?


Totten, r2 = 0.00
velocity
isopycnals
10 weakest slope current years
10 strongest slope current years
Depth (m)
0
400
800
1200
−66.5
−66.0
−65.5
−65.0
Longitude
Temperature (°C)
1
0
−1



Does the Antarctic Slope Current control ocean heat transport towards Antarctica?

- Antarctic Slope Current may be less correlated with southward heat transport than assumed.
- What determines spatial variation in correlations?
- Does the Antarctic Slope Current control heat transport, or is it a passive response to lifted isopycnals?