Davis Strait ocean volume transport variability from 2020 through 2022 using in situ and satellite ocean bottom pressure observations.

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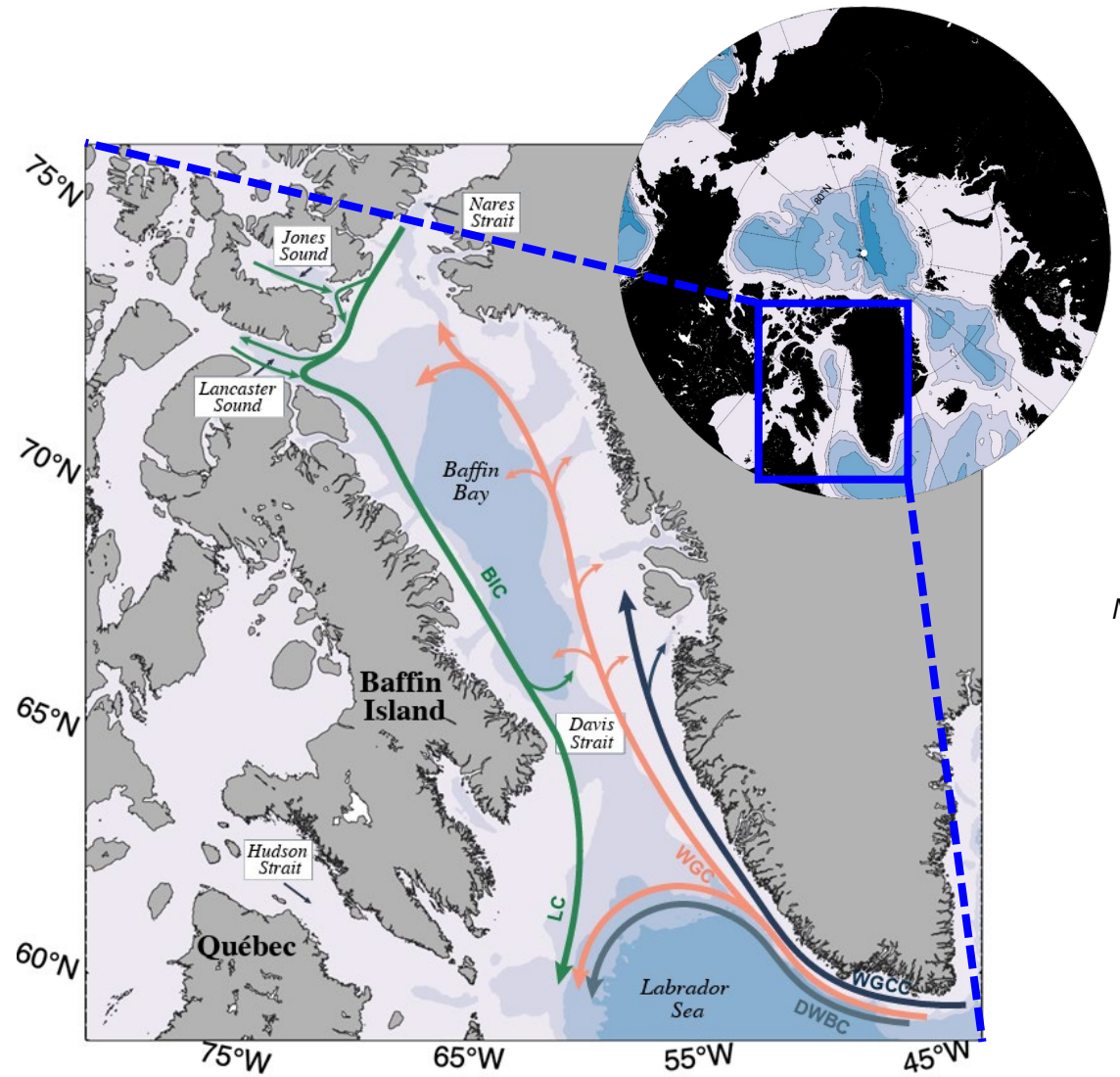
Davis Strait: One of the major Arctic Ocean gateways

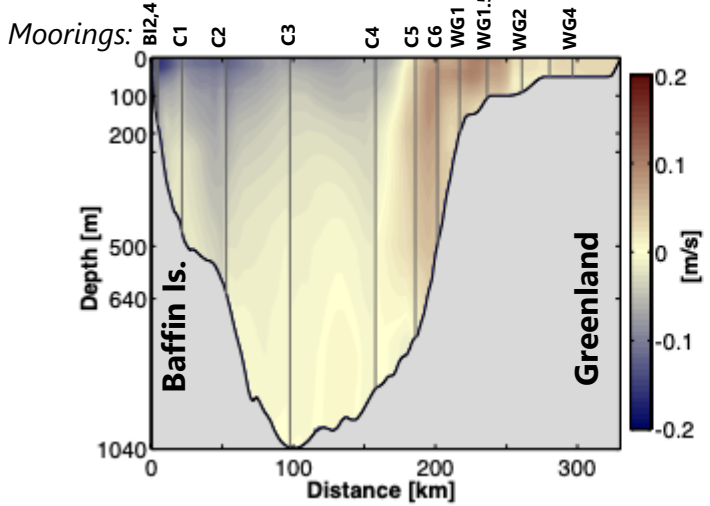


Modified from Curry et al. (2014) and Huang et al. (2024)

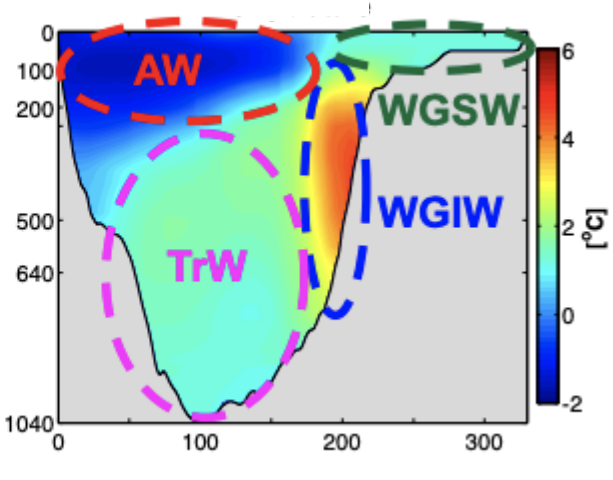
From 2004 to 2017, the UW-led Davis Strait program maintained a mooring array and hydrographic (CTD, glider, …) surveys to study physical & biochemical ocean properties in the region.

- **Annual Transport (2004-10) = -1.6 ±0.5 Sv (1Sv=10^6m/s^3)**
  Curry et al. (2014), JPO
- **Large variability with episodes of net flow reversals.**
  Myers et al. (2021), GRL

Mean velocity (2004-2010)

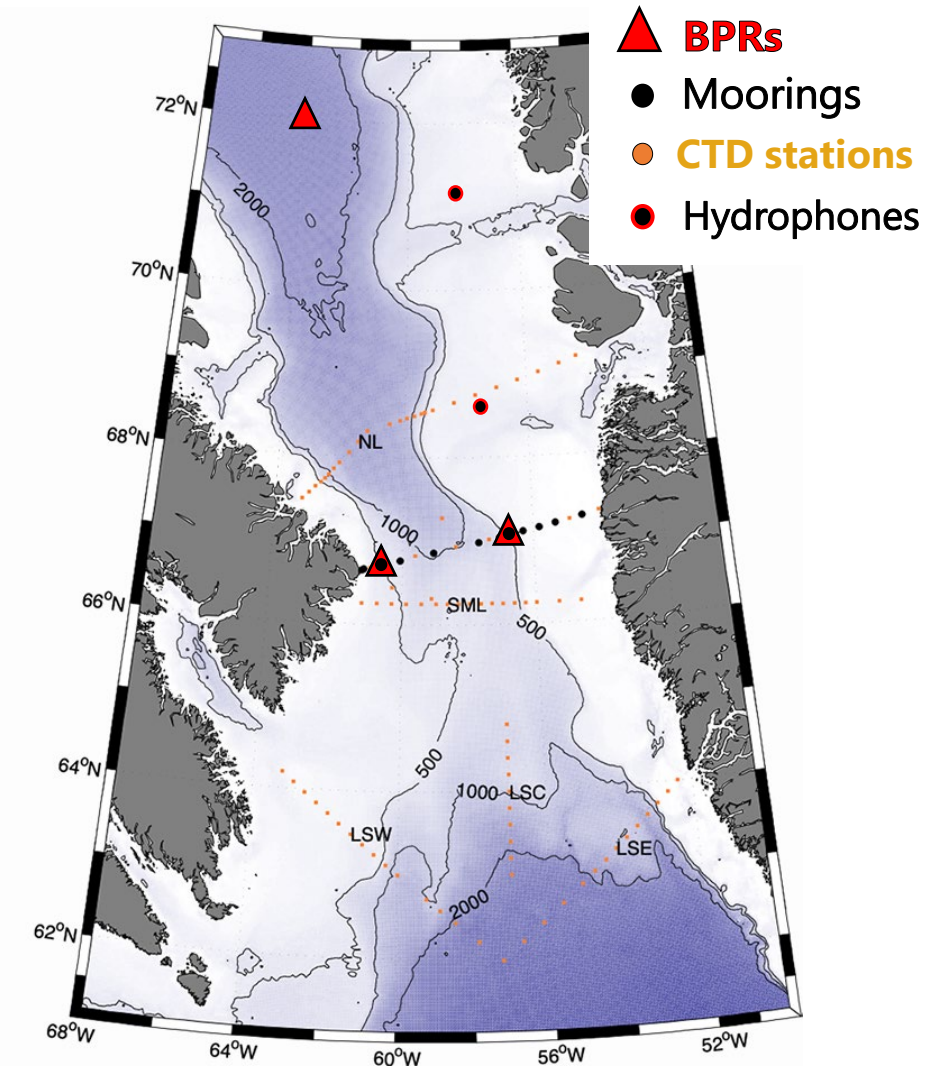


Mean temperature (2004-2010)



Curry et al. (2013), PhD Thesis (University of Washington)

Davis Strait Program: Continuation since 2020

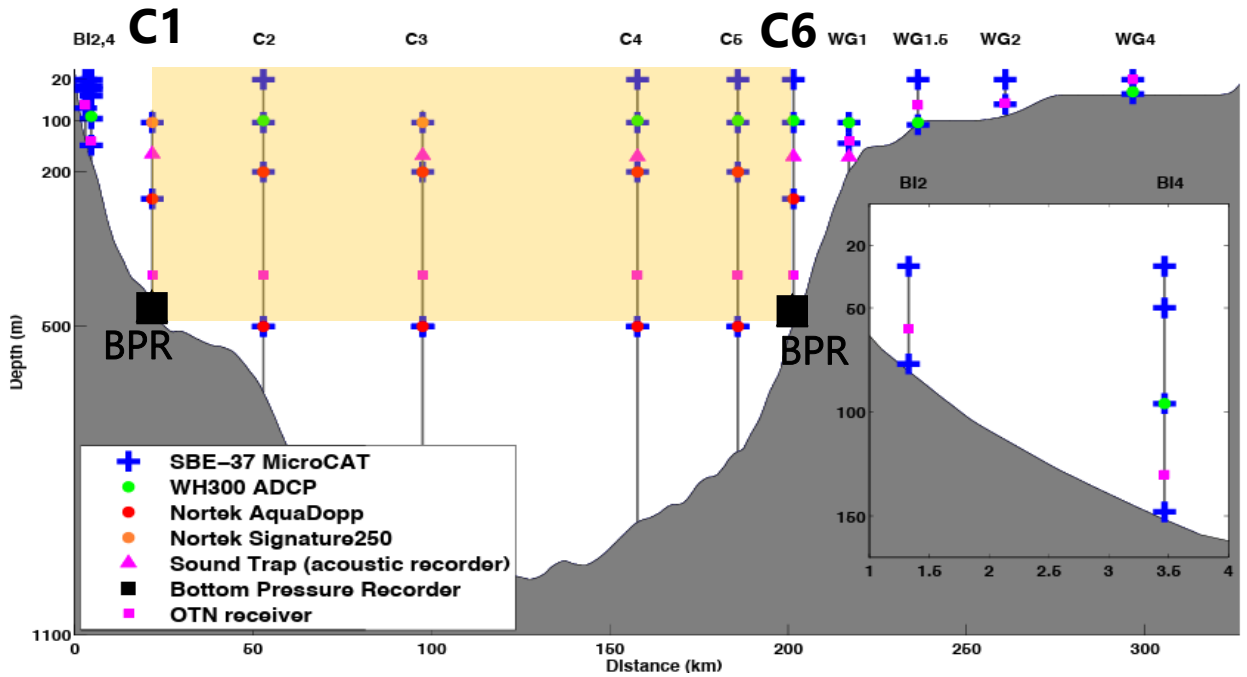


C. Lee et al. (2022), Davis Strait Cruise Report.

Starting in 2020, three Bottom Pressure Recorders (BPRs) were added to the program. BPR goals:

i. Quantify horizontally-averaged meridional volume transport through Davis Strait.

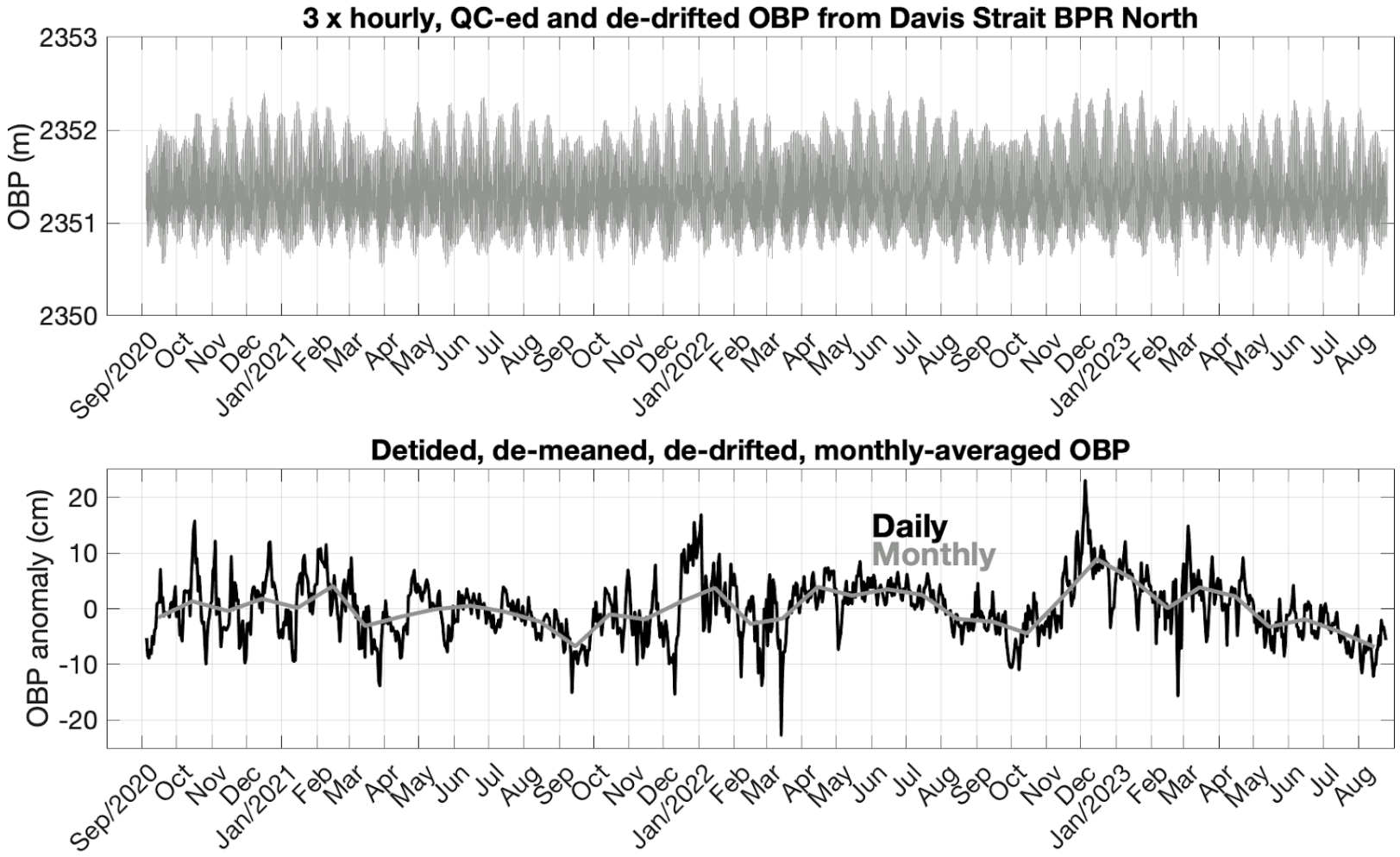
ii. Identify local & far-field drivers of the Davis Strait flow.

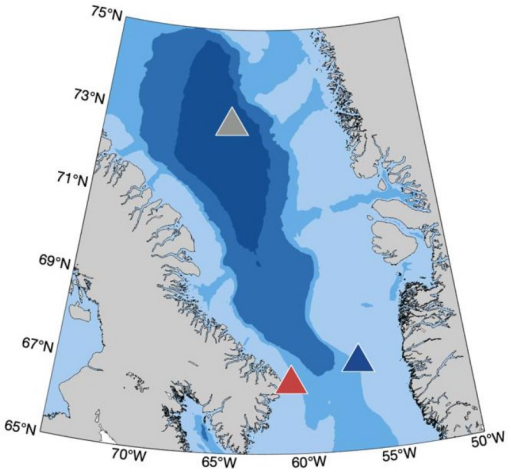


C. Lee et al. (2022), Davis Strait Cruise Report.

Ocean Bottom Pressure (OBP) from BPRs

BPR North on Deep Baffin Bay



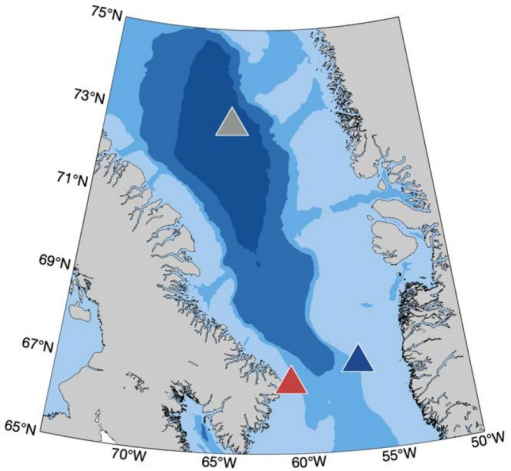


~ 1.5 m peak to peak

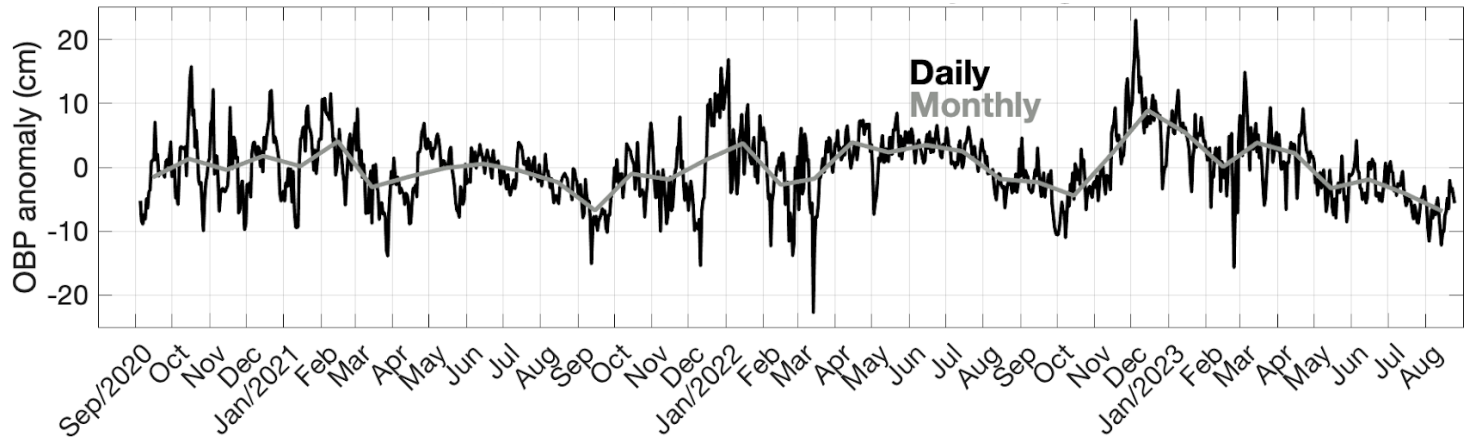
First observations of the tides in the central, deep Baffin Bay.

Larger variations during wintertime (Oct-Mar).

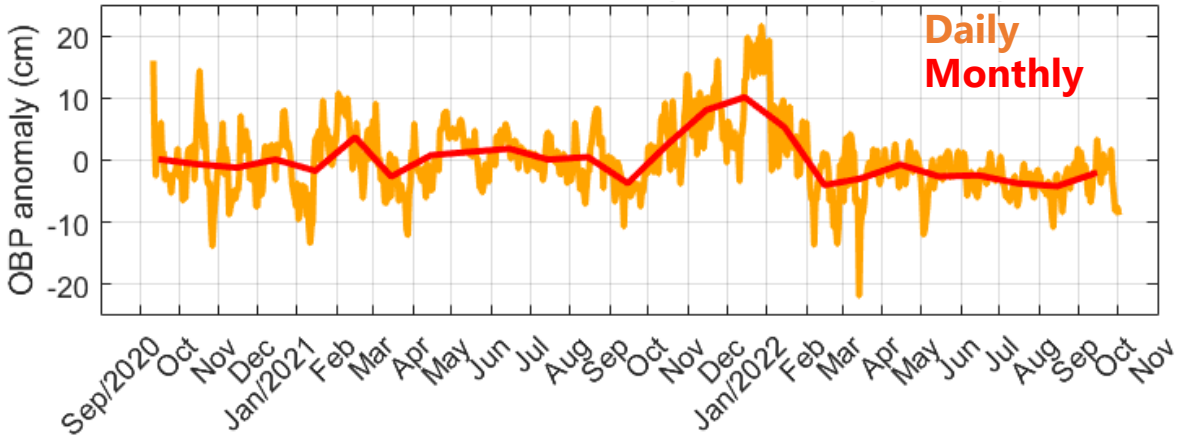
Ocean Bottom Pressure (OBP) from BPRs



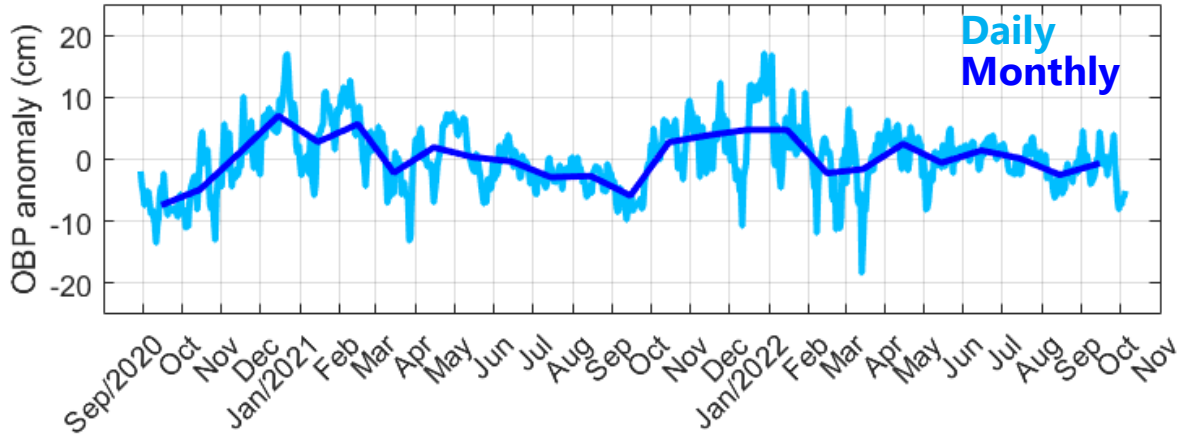
BPR North on Deep Baffin Bay



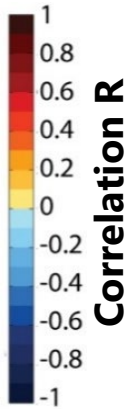
BPR West on Mooring C1

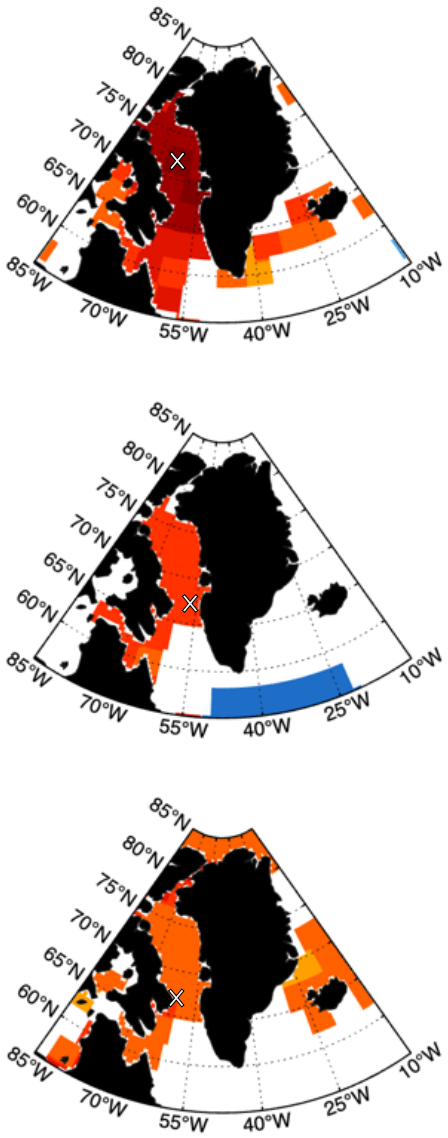


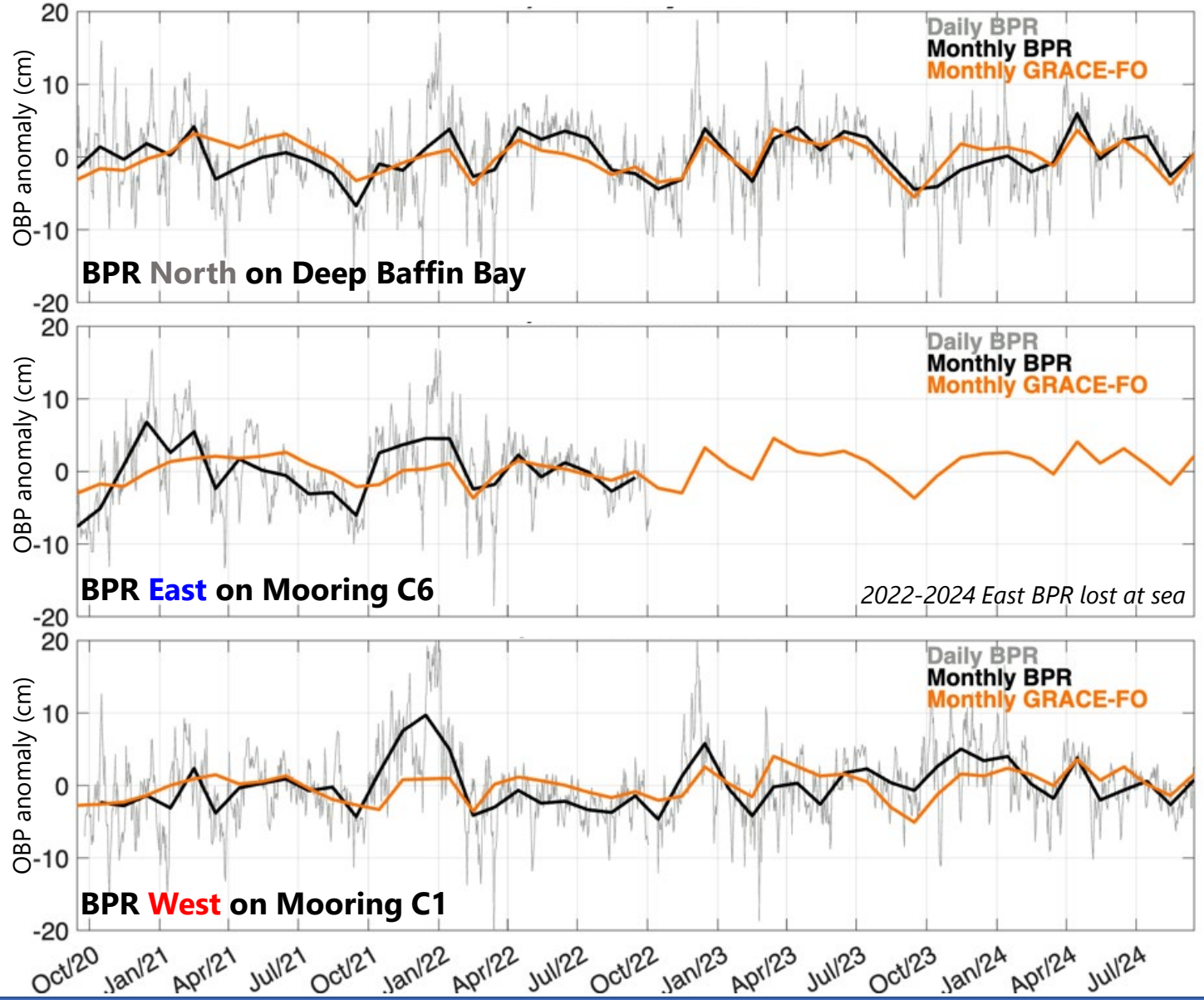
BPR East on Mooring C6

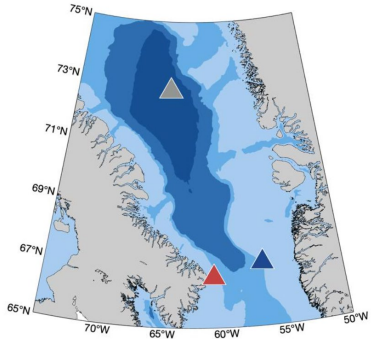


GRACE-FO comparison with Davis Strait & Baffin Bay BPRs









Monthly JPL RL6.3v4 mascons
(*Wiese et al.*, 2023)

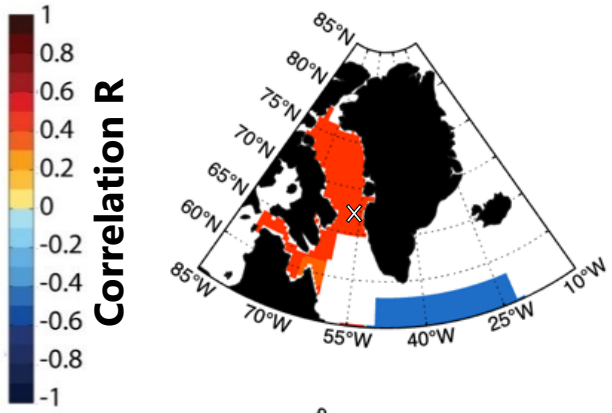
Note 1:

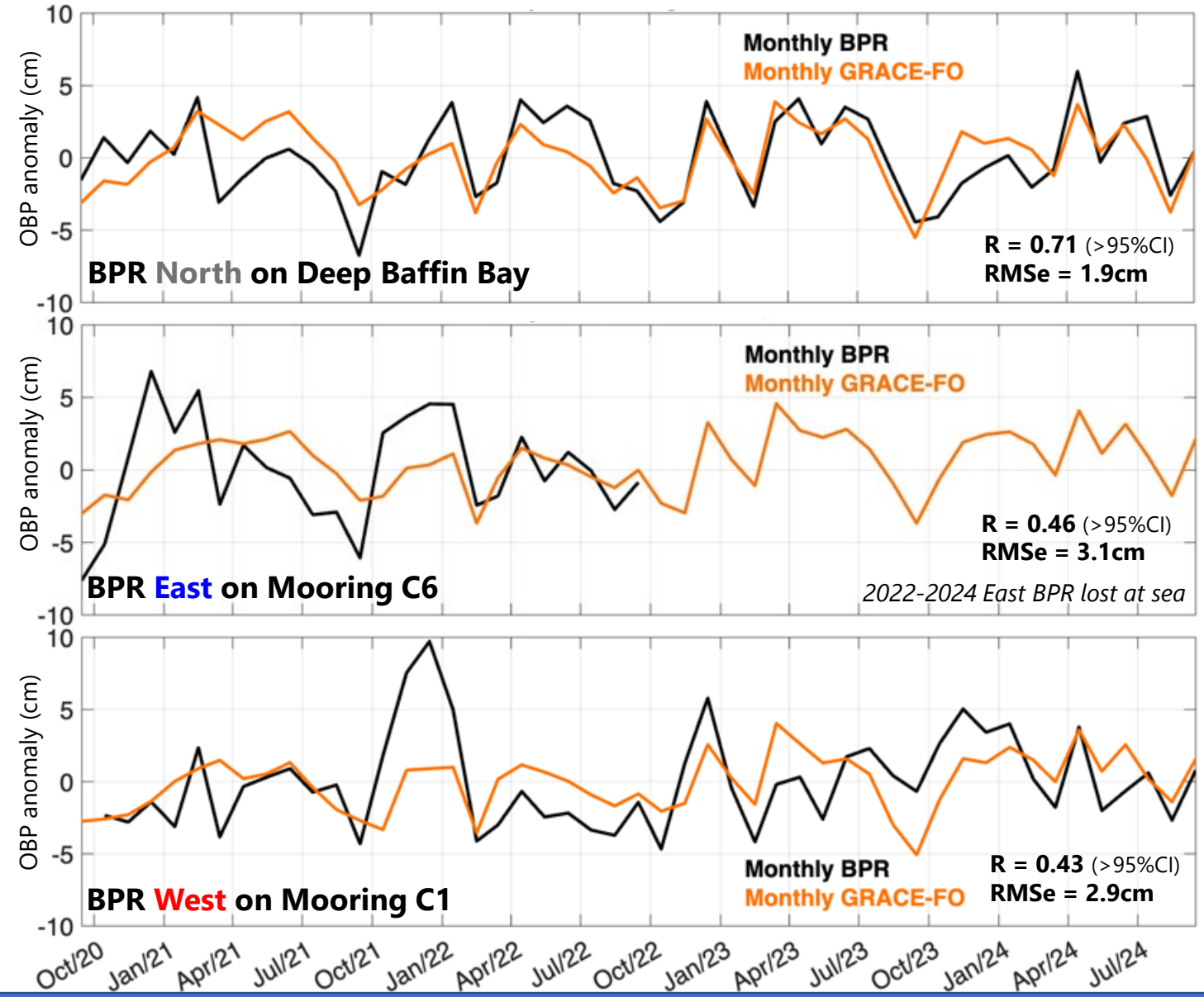
BPRs biennial series shown (2020-22 & 2022-24) were de-spiked, de-drifted, de-meaned, de-tided, averaged daily and monthly, and shifted to match the mean of GRACE-FO series over those two periods.
Seasonal cycles are included in all series.

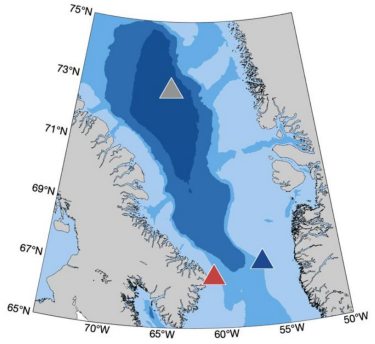
Note 2:

CSR RL6.3 mascons (Save et al., 2022) yield nearly identical correlations to those with JPL mascons. GRACE-FO is de-meaned relative to the overlapping period with BPRs.

GRACE-FO comparison with Davis Strait & Baffin Bay BPRs







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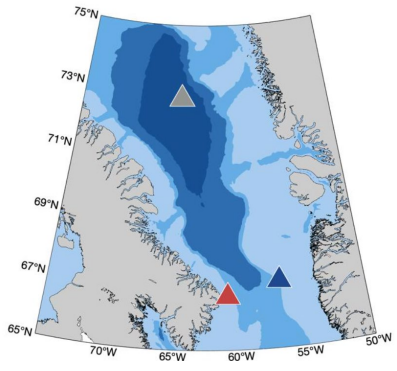
BPR-derived meridional transport

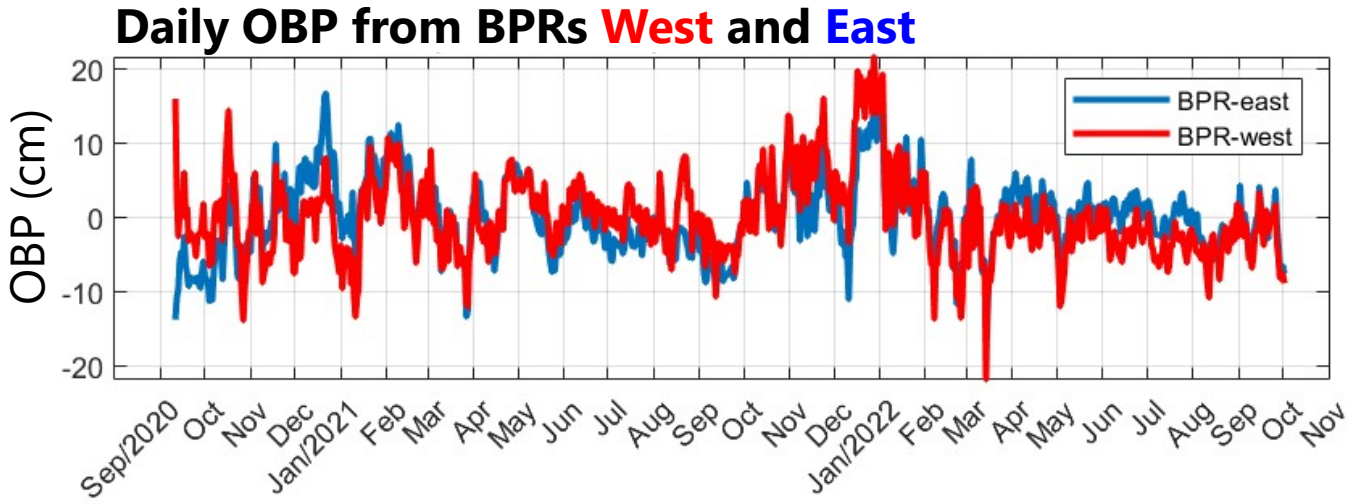
Horizontally-averaged meridional volume transport through Davis Strait is estimated from BPRs **West** and **East** from Sept 2020 through Sept 2022.

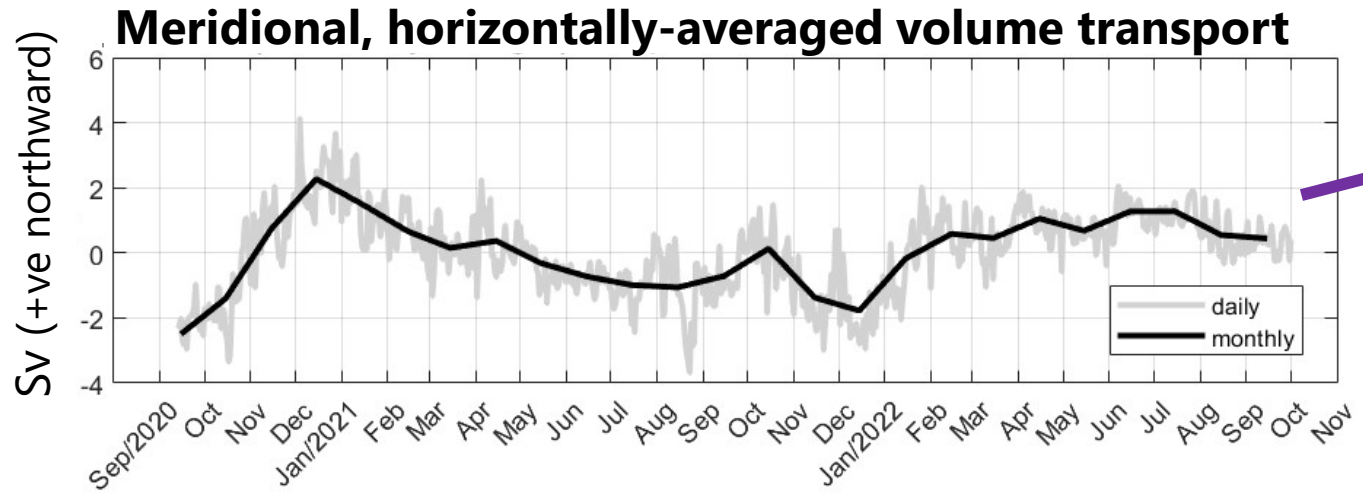


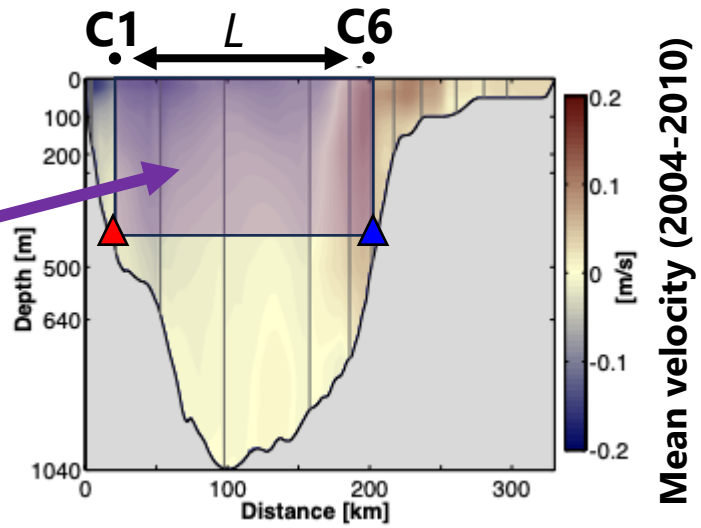
Barotropic Transport:

$$T' = \bar{v}'HL = \frac{H}{\rho f}\Delta p'$$

v = Merid. Geostr. velocity
L = Distance between BPRs
H = Depth of BPRs: *450 m*
ρ = water density
Δp = OBP difference
f = Coriolis term

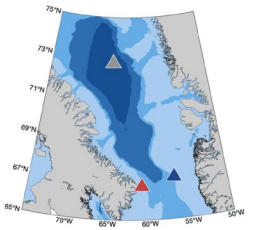




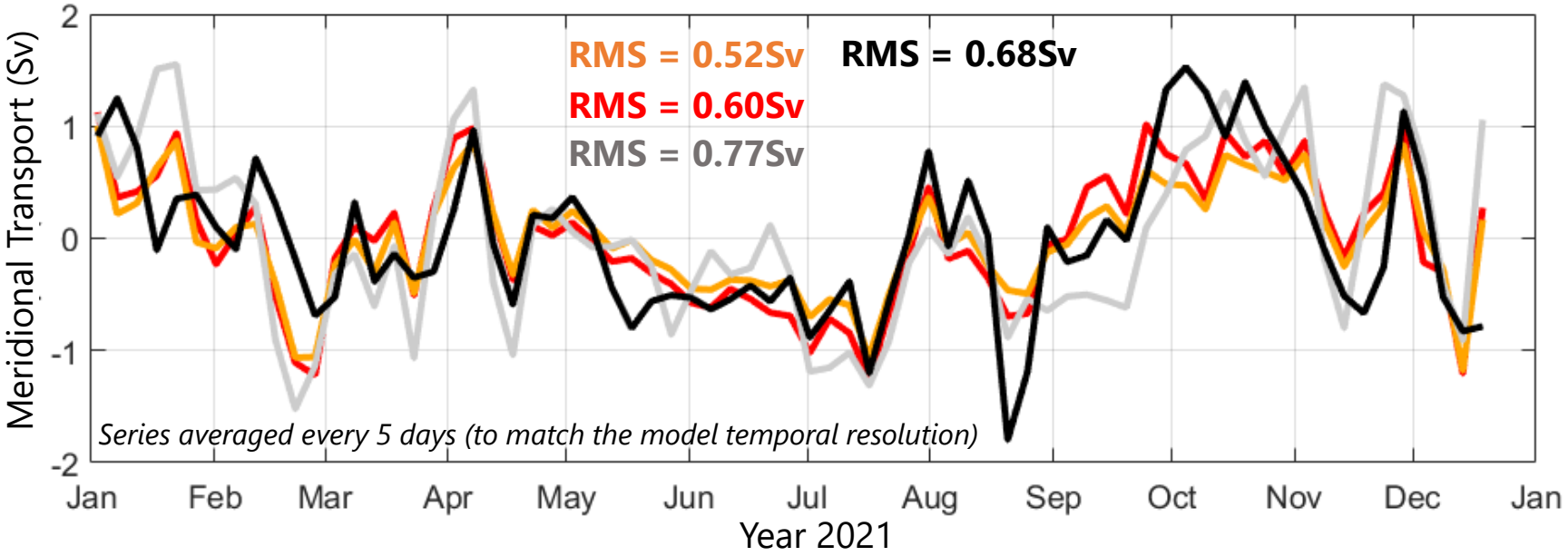


Curry et al. (2013), PhD Thesis (UW)

Model simulations vs BPR-derived DS transport



1-year ANHA12 simulations: NEMO-framework, 1/12th degree (*Meyers et al.* (2021), JGR)
Horizontal Res: 6.0 km (Labrador Sea) to 4.0 km (Baffin Bay), well validated by *in situ* velocity data (*Hu et al.*, 2018).



BPR-derived transport

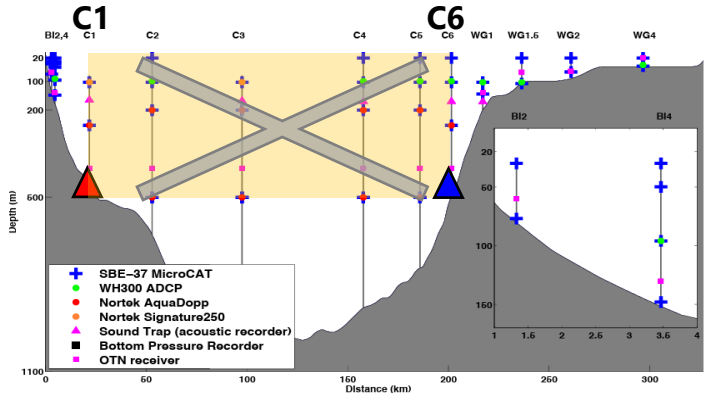
ANHA12 C1 to C6 Top450m
R = 0.73 w/BPRs transport

ANHA12 C1 to C6
R = 0.75 w/BPRs transport

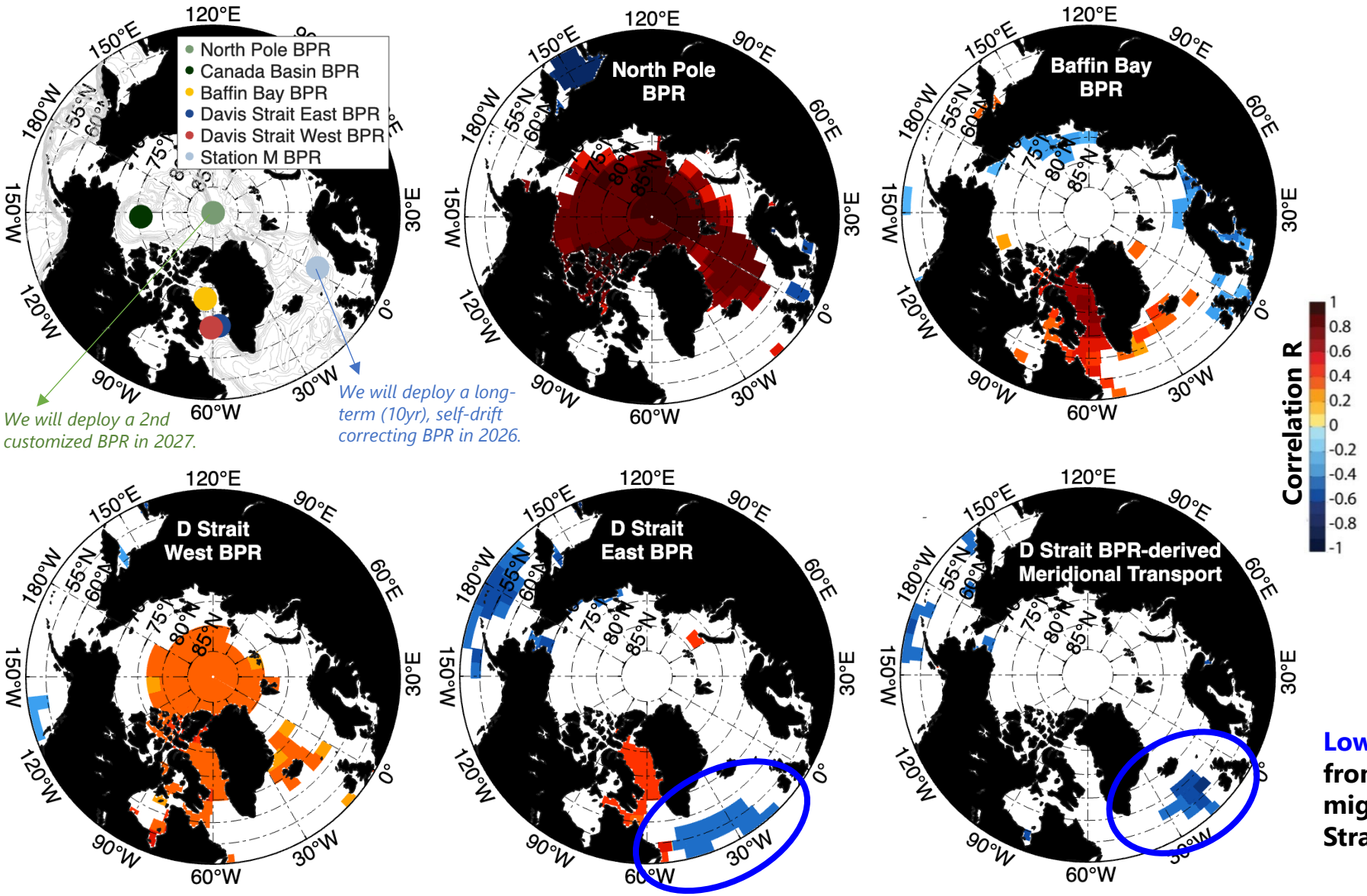
ANHA12 Total DS transport
R = 0.64 w/BPRs transport

The model vs BPR-derived Davis Strait transport comparisons show:

- BPR-derived meridional volume transport is relatively well captured by the model.
- BPRs get >90% of the full-depth meridional transport variability between C1-C6.
- Simulated <u>total</u> DS transport is significantly correlated with BPR-derived transport.
- Model suggests BPRs may capture ~70% of the total DS meridional flow variability:
  The D Strait mooring array could be potentially simplified by excluding the moorings east of C1 and west of C6.



GRACE-FO helps identify drivers of the flow



Correlation Coefficient (R) maps between GRACE-FO and various BPRs using monthly JPL RL6.3v4 mascons (*Wiese et al.*, 2023)

CSR mascon RL6.3 (Save et al., 2022) yields nearly identical results to JPL mascons.

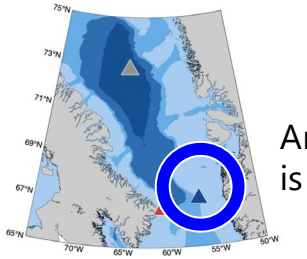
North Pole BPR OBP (2022-2023) is very highly correlated with Arctic-wide GRACE-FO OBP (*Peralta-Ferriz et al.*, 2013; 2016)

1yr of North Pole BPR data, 2022-2023:
https://podaac.jpl.nasa.gov/dataset/GRACE_ABPR_FO_L2_V1.0
Unfortunately, this BPR is no longer functional.

In Baffin Bay, a very challenging region for accurate satellite OBP solutions (*Bonin and Chambers, 2013*)**, BPRs are significantly correlated with GRACE-FO, particularly the BPR in deep Baffin Bay.**

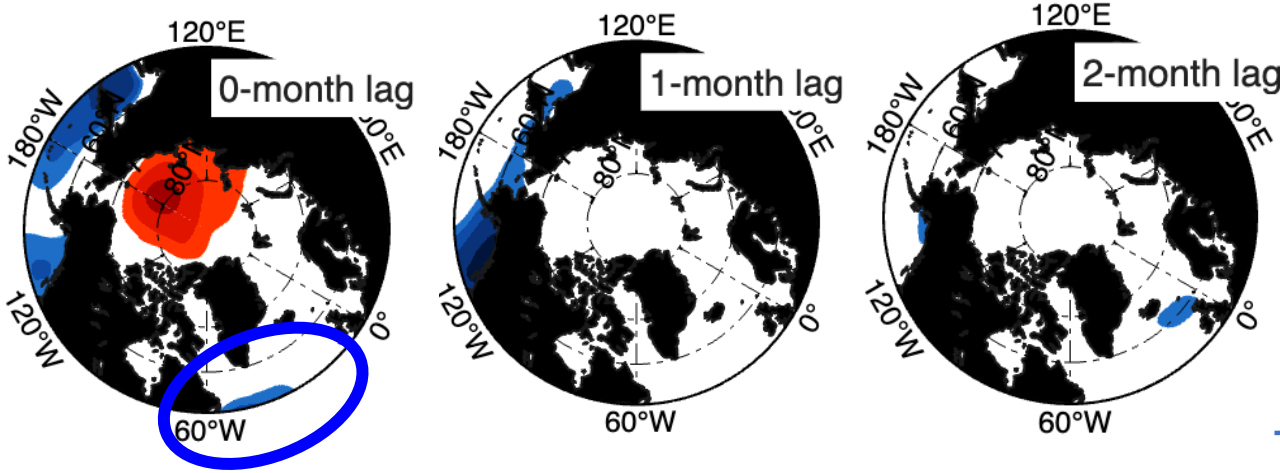
Low OBP in the North Atlantic, resulting from the presence of the Icelandic Low might be related to the meridional Davis Strait transport.

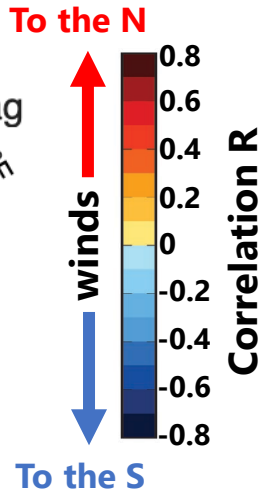
Atmospheric forcing (sub-seasonal scales)



Analysis shown here and onward is with **BPR east**.

Monthly lagged correlations of: BPR East with ERA5 Sea Level Pressure

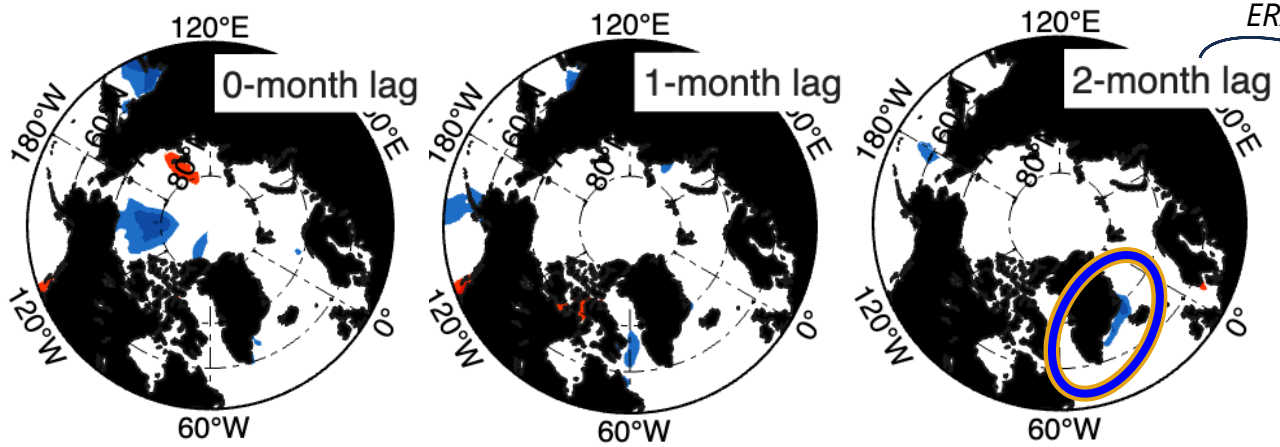




Arctic high SLP and low SLP in the Labrador Sea are linked to increased OBP in East Davis Strait

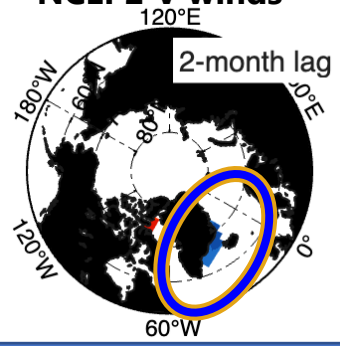
Along-coast winds in SE Greenland drive Coastally Trapped Waves (CTW) (*Gelderloos et al.*, 2021). **CTW response is observed at moorings downstream in the S Greenland shelf/slope** (*Pacini et al.*, 2020).

BPR East with ERA5 Meridional (V) 925mb winds



ERA5 is consistent with NCEP2:

NCEP2 V winds



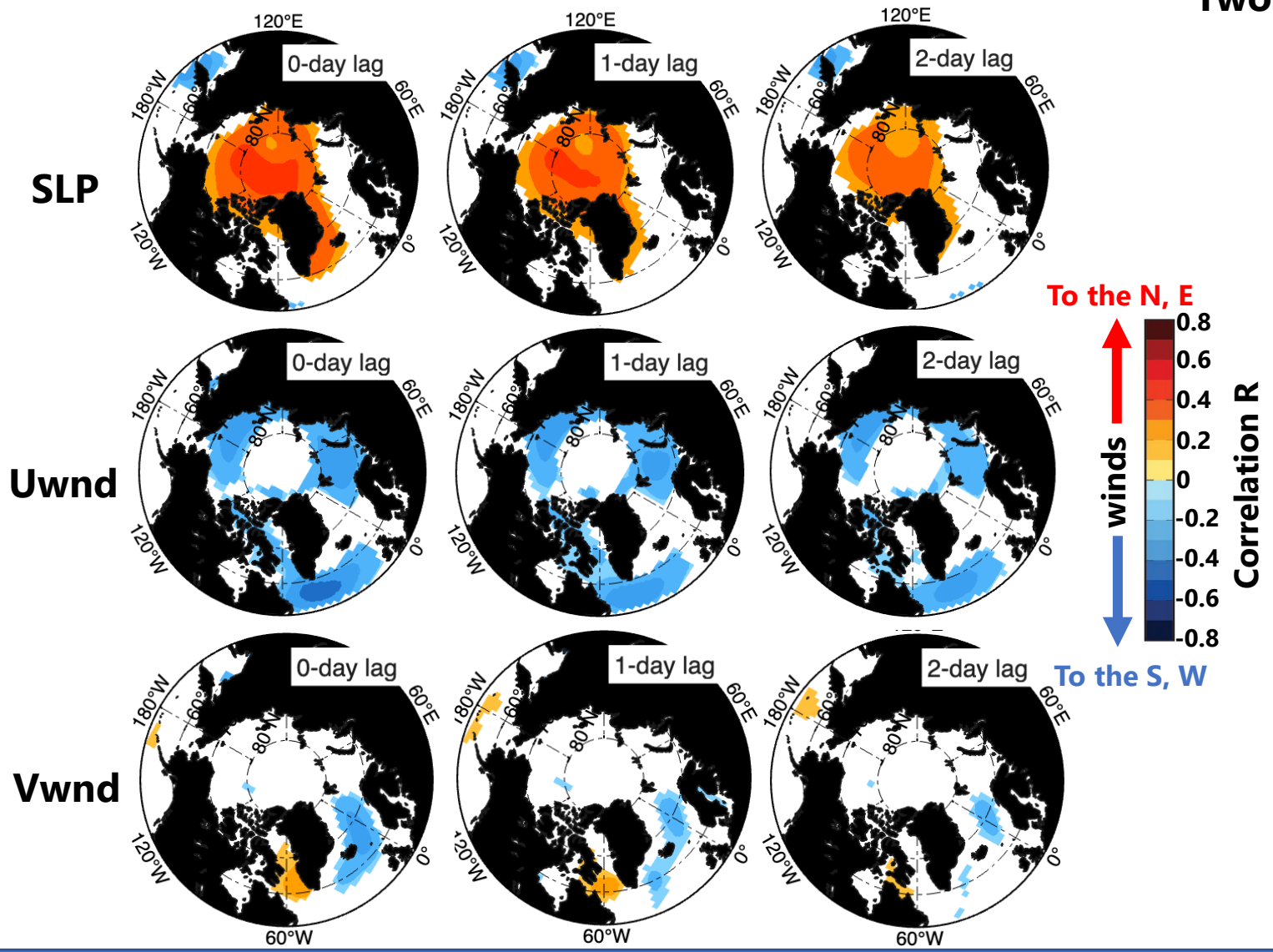
CTW Barotropic phase speed ~ 3.5 m/s
Baroclinic phase speeds ~ 0.14 - 0.44 m/s

To travel ~3000 km to BPR East:
Barotropic response ~ 8-10 days
Baroclinic response ~ 280 – 60 days
(We see this baroclinic signal at the 2-month lag.)

Do the BPRs capture the faster (8-10 day) barotropic response?

Atmospheric forcing at shorter (day - few days) timescales

Daily lagged correlations of OBP from BPR East with NCEP2

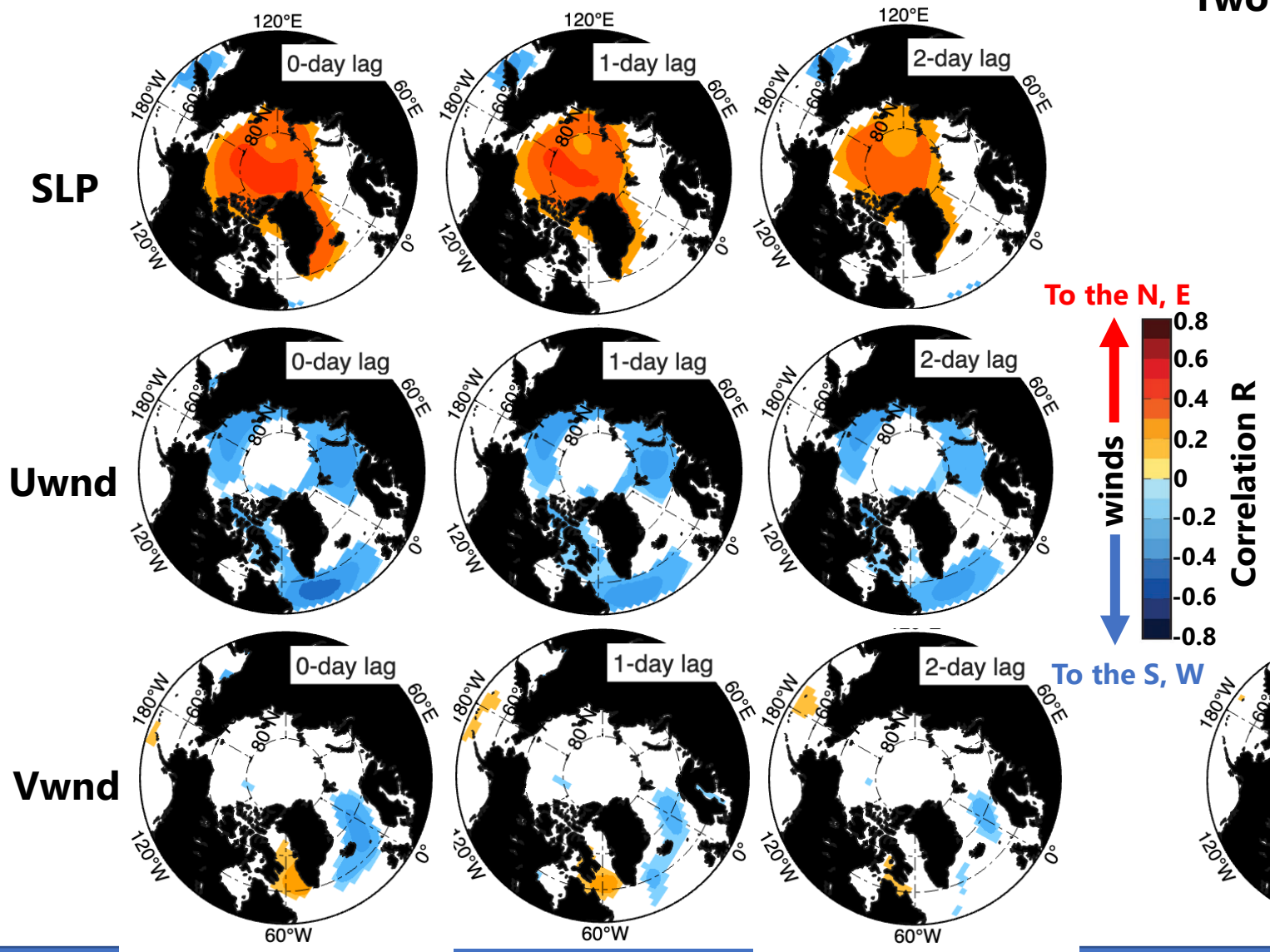


Two driving mechanisms revealed:

1. Arctic (and sub-Arctic) high SLP enhances anomalously westward winds along 50-55N, and northward winds along West Greenland, increase northward flow through the strait within a day.

Atmospheric forcing at shorter (day - few days) timescales

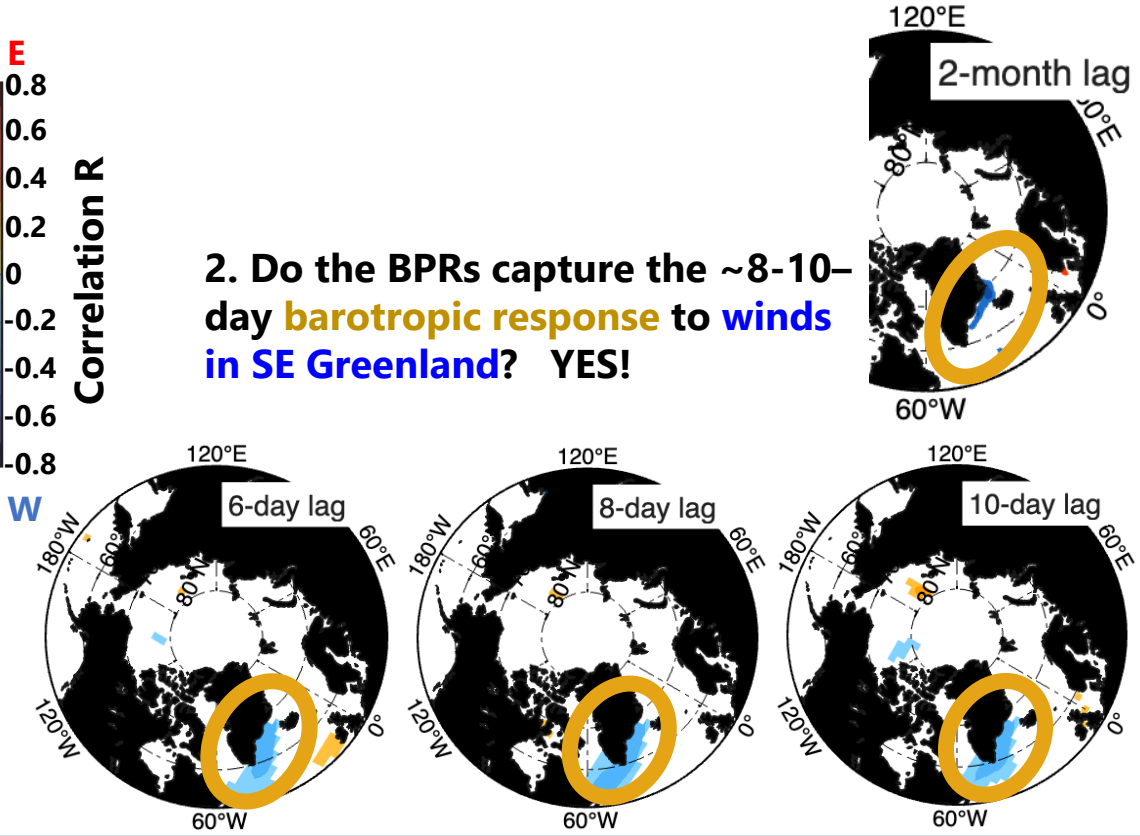
Daily lagged correlations of OBP from BPR East with NCEP2



Two driving mechanisms revealed:

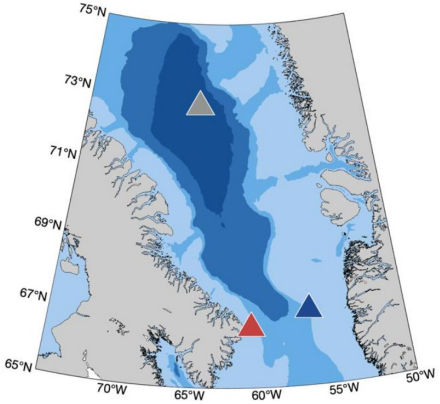
1. Arctic (and sub-Arctic) high SLP enhances anomalously westward winds along 50-55N, and northward winds along West Greenland, increase northward flow through the strait within a day.

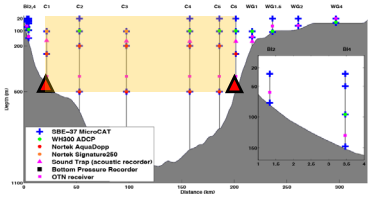
2. Do the BPRs capture the ~8-10–day barotropic response to winds in SE Greenland? YES!



Summary

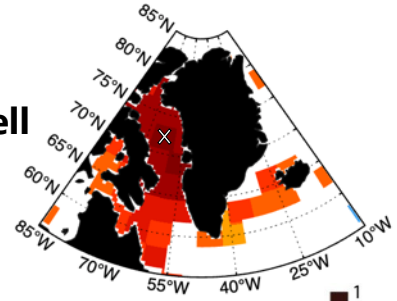
1. Since 2020, three BPRs as part of the Davis Strait Program have provided insight on the drivers of the Davis Strait flow variability.

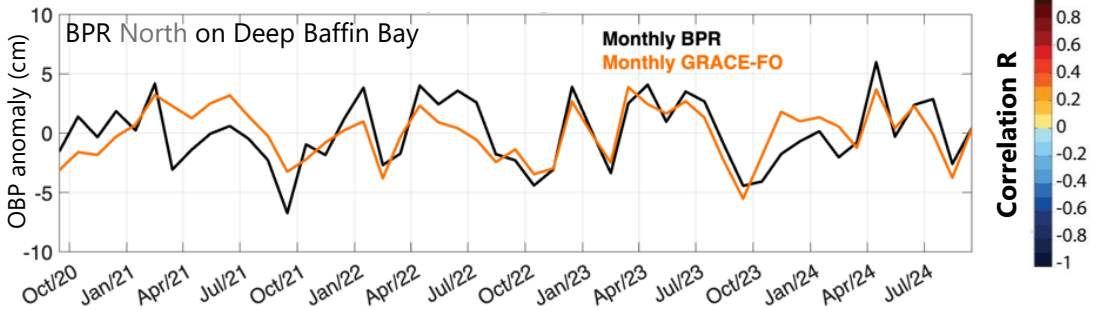




2. The BPRs W and E likely capture most of the total meridional Davis Strait flow variability.

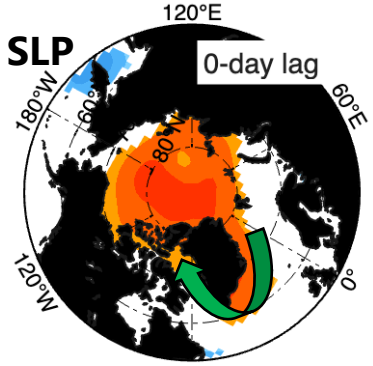
3. GRACE-FO (JPL & CSR masc) is well correlated with BPRs in the Davis Strait region, especially in the northern deep Baffin Bay.

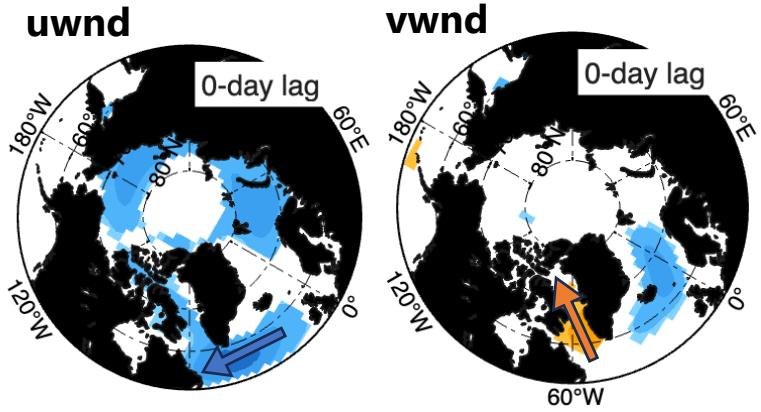




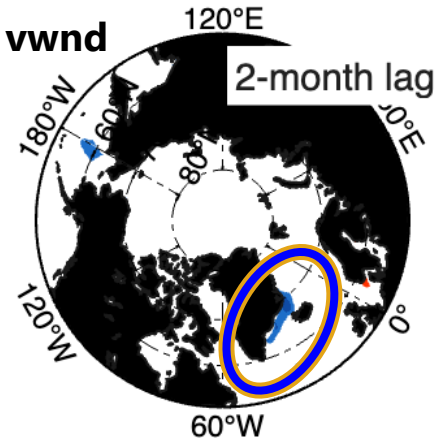
4. BPR records, combined with GRACE-FO and atmospheric reanalysis products, reveal 2 forcing mechanisms driving the Davis Strait flow variability:

4.i Arctic High SLP that strengthens anti-cyclonic winds along S Greenland: *Ocean response (likely a slope current) in the strait within 1 day.*





4.ii Strong southward winds along SE Greenland generate *Coastally Trapped Waves with an ocean response in the strait in ~6-10 days (barotropic) and in ~2 months (baroclinic).*



Peralta-Ferriz, et al., in prep.

Thank you!