Recent Davis Strait transports and changes since the late 1980s

Beth Curry[1], Craig Lee[1], Brian Petrie[2], Dick Moritz[1], Ron Kwok[3]

[1]Applied Physics Laboratory, University of Washington

[2]Bedford Institute of Oceanography

[3]Jet Propulsion Laboratory, California Institute of Technology

CONTACT: beth4cu@uw.edu

1 Introduction

Davis Strait and Fram Strait are the two main gateways between the Arctic and North Atlantic Oceans.

Quantifying transport through Davis Strait is important for assessing Atlantic meridional overturning circulation sensitivity to Arctic freshwater inputs.

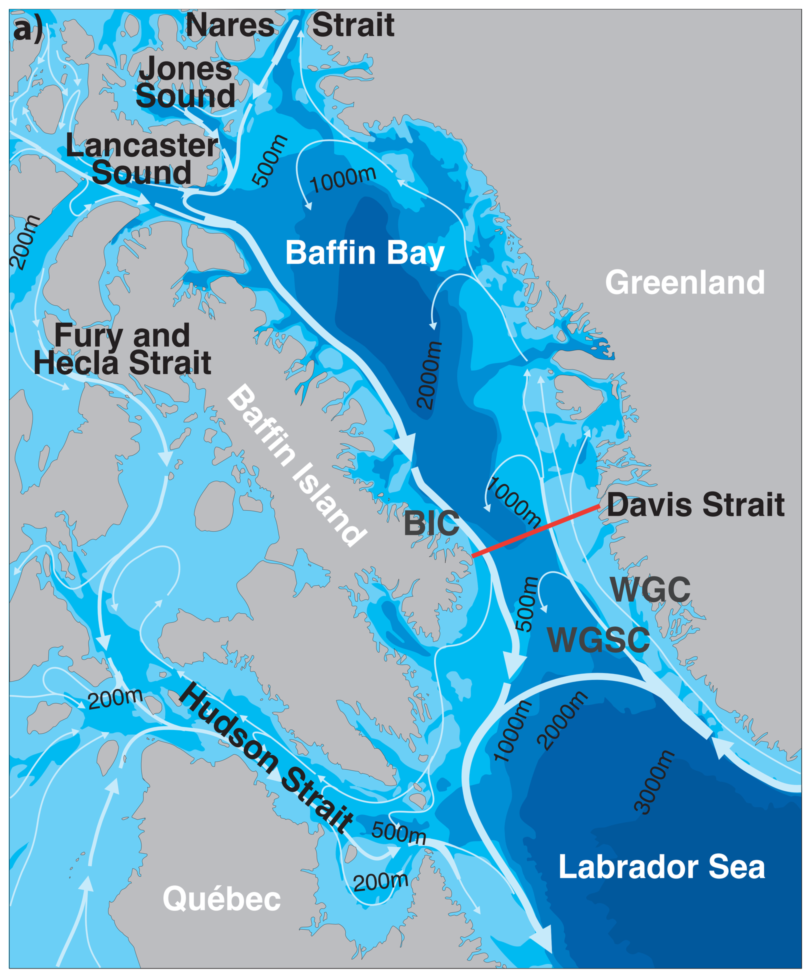
Net Davis Strait outflow combines Canadian Arctic Archipelago (CAA) inflows, river runoff, sea ice and inputs from Greenland and the North Atlantic after being modified during their southward transit through Baffin Bay to the Labrador Sea.

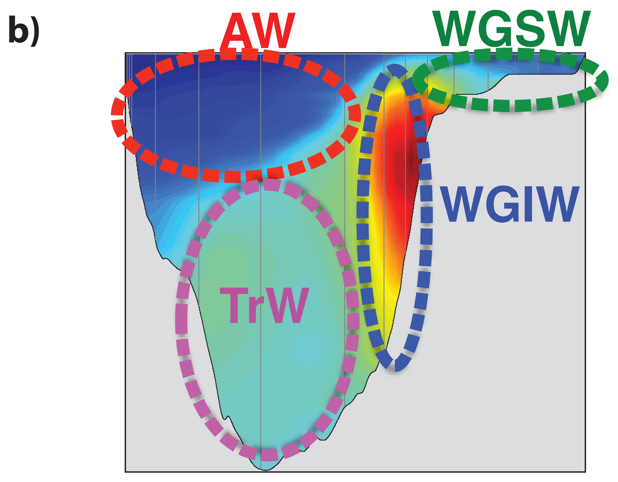
Freshwater outflow from Davis Strait into the Labrador Sea may enhance deep convection by increasing ice cover which would increase the heat flux from the ocean to the atmosphere (Våge et al., 2009), inhibit convection by creating stable stratification (Goosse et al., 1997), or play no role in convection by staying confined to the shelf and slope and having little exchange with deep convection areas (Myers, 2005).

Changes in Arctic freshwater export can initiate dramatic regime shifts in the continental shelf ecosystems of the western North Atlantic (Greene et al., 2008).

Warm North Atlantic inflows into Baffin Bay have been linked to subsurface glacial erosion off the coast of central West Greenland (Rignot et al., 2010).

2 Circulation and Water Masses





Water Masses

Arctic Water (AW)
$\theta \leq 2\,°C$ $S < 33.7$

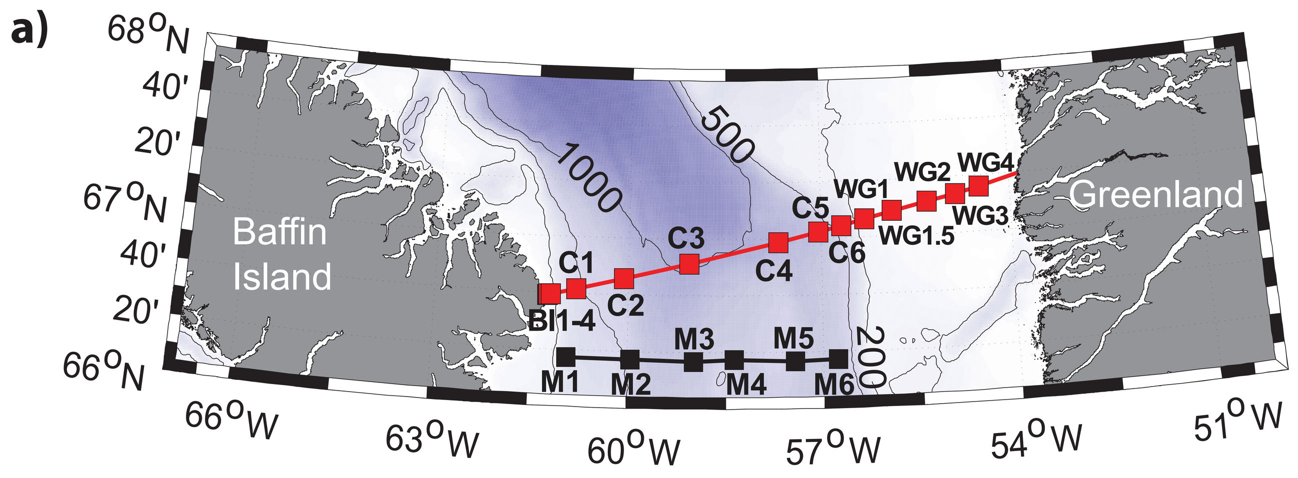
West Greenland Irminger Water (WGIW)
$\theta > 2\,°C$ $S > 34.1$

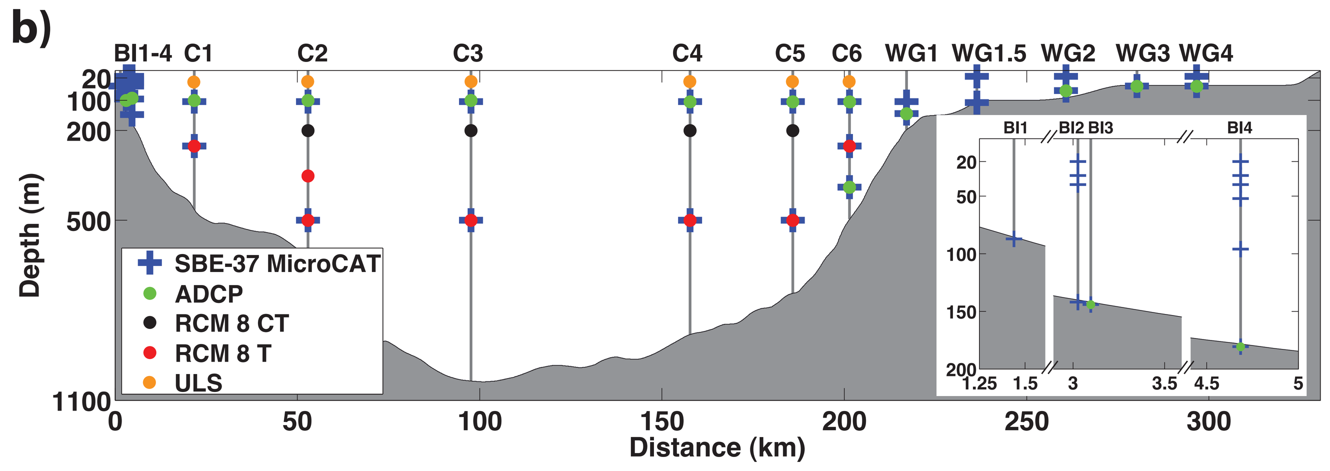
West Greenland Shelf Water (WGSW)
$\theta < 7\,°C$ $S < 34.1$

Transitional Water (TrW)
$\theta \leq 2\,°C$ $S > 33.7$

(a) General circulation in Baffin Bay and Davis Strait (white arrows) and the location of the 2004-10 moored array (red line). Arctic water leaves Davis Strait as the broad, surface-intensified Baffin Island Current (BIC). Northward flow on the eastern side of Davis Strait consists of the fresh West Greenland Current (WGC) of Arctic origin on the shelf and warm, salty West Greenland Slope Current (WGSC) of North Atlantic origin on the slope.
(b) Four main water masses in Davis Strait defined based on potential temperature and salinity following Tang et al. (2004). Water masses are spatially delinated on top of the average December temperature cross-section where red indicates warm water and blue indicates cold water.

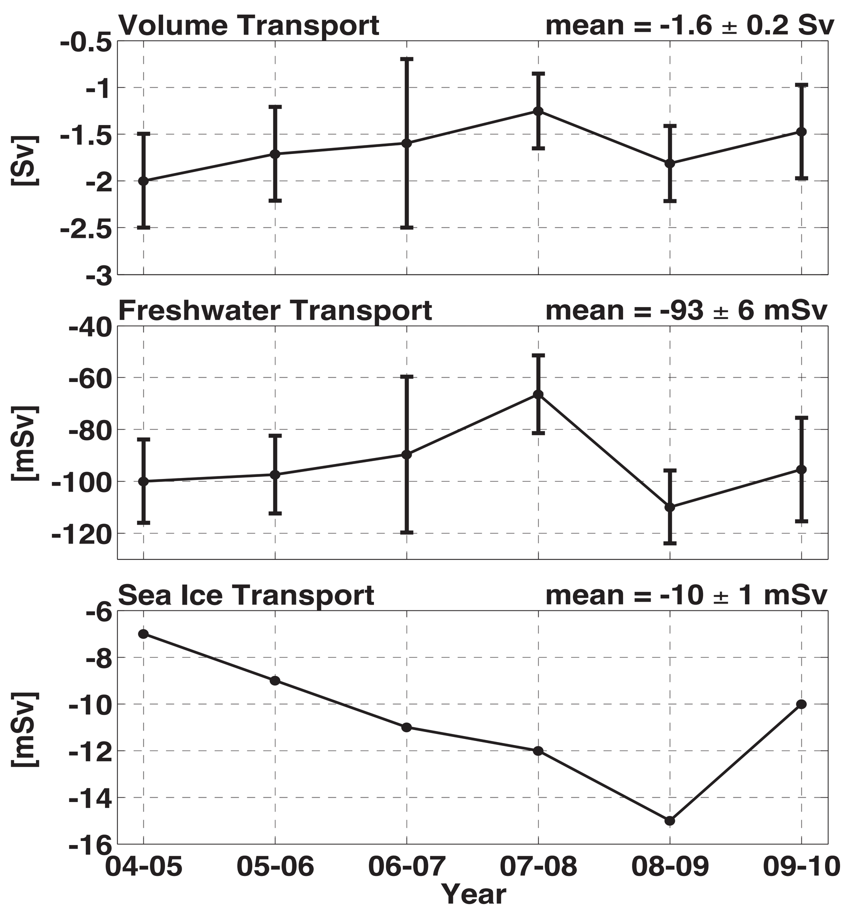
3 Observational Program





(a) Davis Strait 2004-2010 (red line) and 1987-1990 (black line) year-round moored arrays with squares indicating mooring locations. The 1987-90 array consisted of five moorings each year (M4 was relocated to M5 after the first year) containing Aanderaa RCM5 velocity, conductivity and temperature recorders at 150, 300 and 500 m. (b) Summary of Davis Strait 2004-2010 moored array instrumentation. Blue crosses indicate SBE37 MicroCAT conductivity, temperature and pressure recorders; green dots represent RDI ADCPs; black dots denote Aanderaa RCM8 velocity, conductivity, and temperature recorders; red dots denote Aanderaa RCM8 velocity and temperature recorders; and orange dots denote ULSs. Inset image shows a close-up of the Baffin Island shelf instruments. Spatial coverage varies from year to year throughout the program, particularly on the shelves. In September 2005 concurrent high-resolution Seagliders surveys were added to the monitoring program to resolve temperature and conductivity variability at scales smaller than the mooring separation distances.

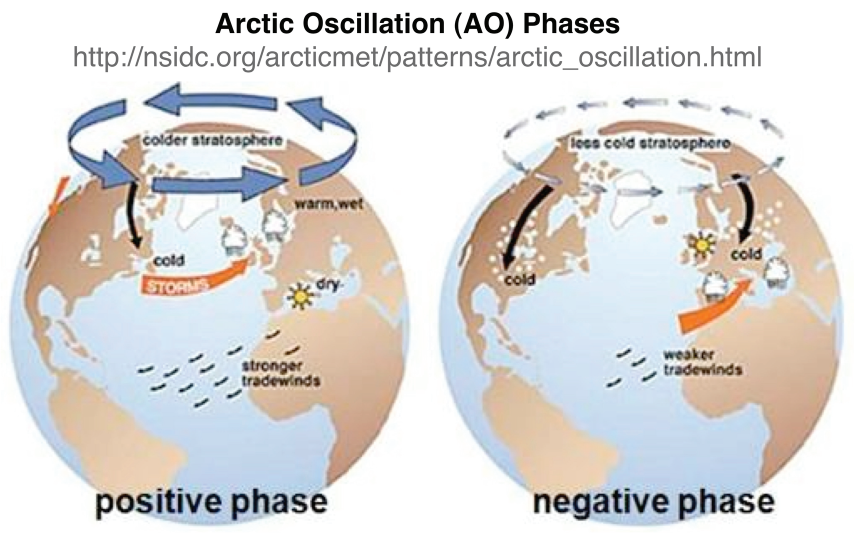
4 2004-10 Net Transports

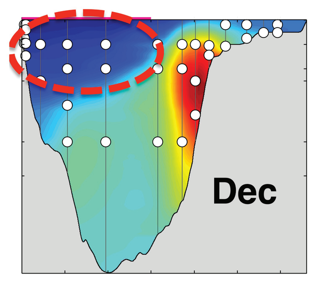


Objectively analyzed yearly volume, liquid freshwater and sea ice transports and uncertainties between October 2004 and September 2010 (negative = southward transport). Freshwater transport is referenced to 34.8. All transports are estimated from the surface to the sill depth, 640 m. November to May sea ice volume transport is estimated for each year by combining daily sea ice area transports, estimated using AMSR-E satellite data, with ice thicknesses derived from moored upward looking sonar data. Yearly ice volume transports include an additional 0.5 mSv to account for ice transport between June and July (Jordan and Neu, 1982).

6 Possible Drivers of Change Between 1987-90 and 2004-10

Changes in Arctic Circulation

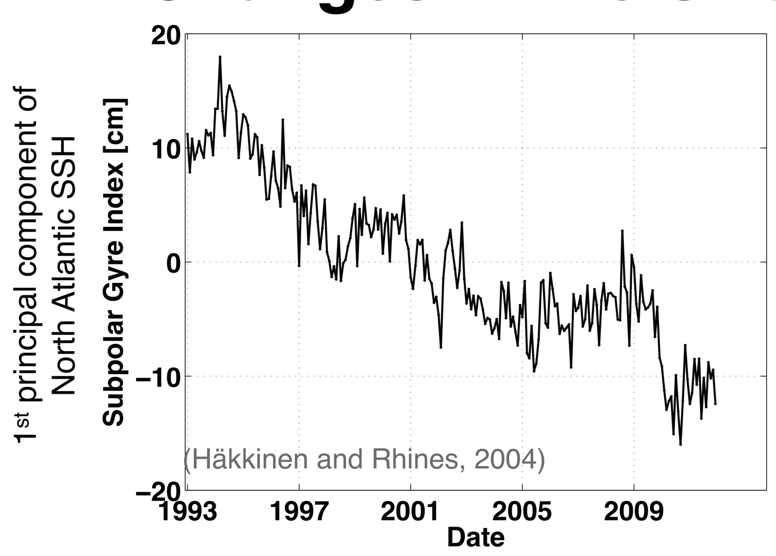


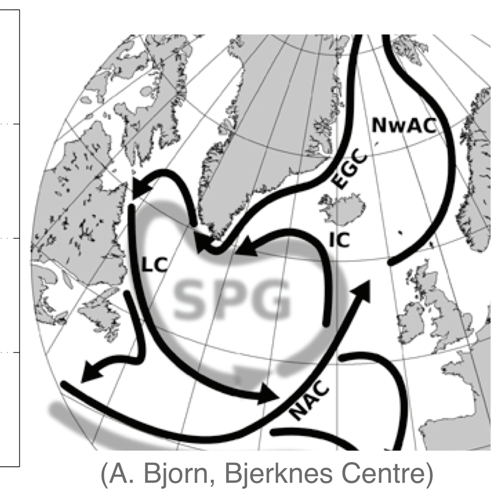


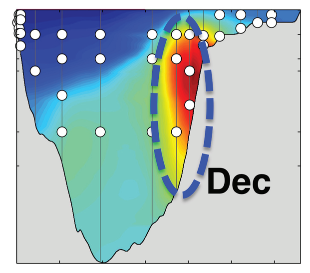
	Volume Transport (Sv)	
Year	Net Central	AW
1987-90 (+AO)	-3.5	-2.2
2004-10 (-AO)	-2.0	-1.7

Southward transport of AW has decreased between 1987-90 and 2004-10, consistent with variations in the AO index. The average AO index (January-March) was positive between 1987-90 which indicates an increase in cyclonic atmospheric circulation causing the anticyclonic Beaufort Gyre to weaken and release freshwater from the Arctic to the North Atlantic. Conversely, the average AO index was negative between 2004-10 which indicates a decrease in cyclonic atmospheric circulation causing an increase in Arctic freshwater storage and a freduction of freshwater outflow.

Changes in the Subpolar Gyre



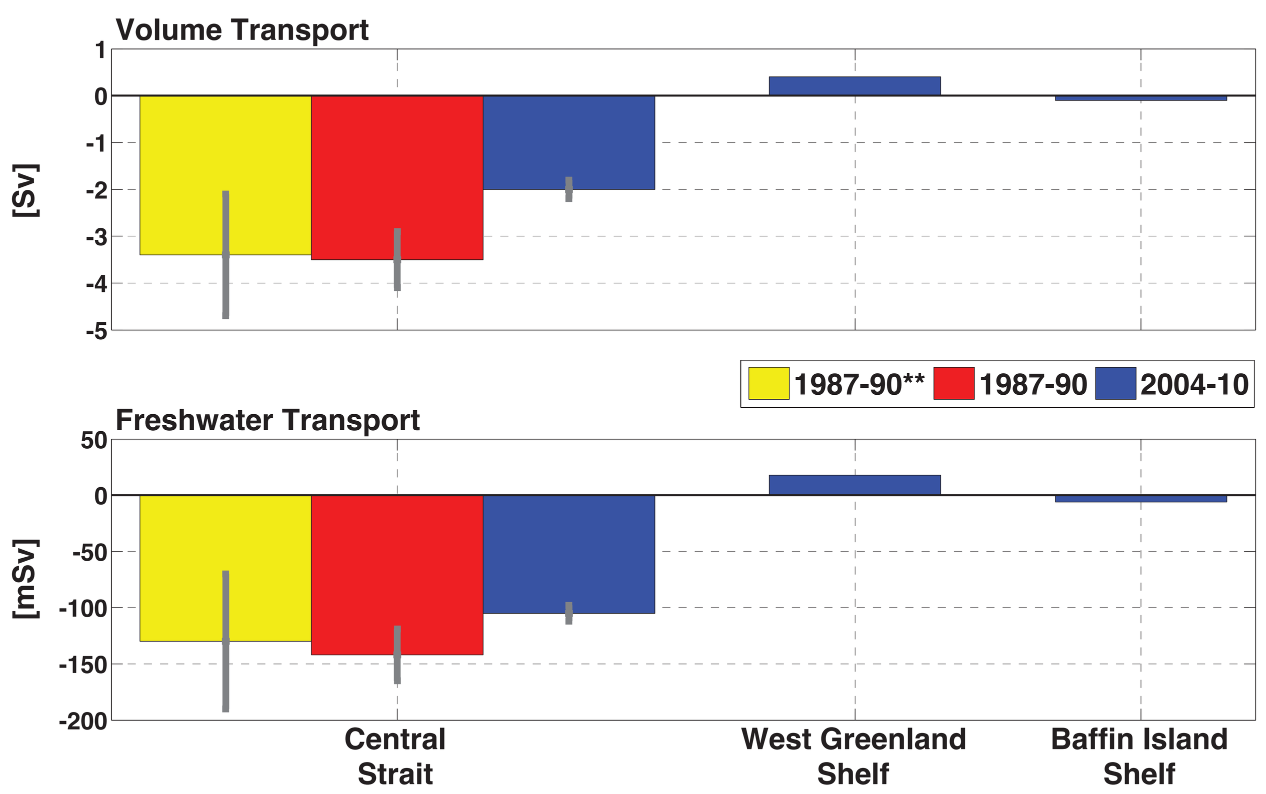




	Volume Transport (Sv)	
Year	Net Central	WGIW
1987-90 (+SPG)	-3.5	0.1
2004-10 (-SPG)	-2.0	0.7

The recent increase in WGIW transport is consistent with a weaker subpolar gyre as compared to the early 1990s. A positive subpolar gyre index indicates a stronger, expanded subpolar gyre. Conversely, a negative index indicates a weaker, contracted subpolar gyre. The subpolar gyre has weakened since the early 1990s, causing it to contract and move westward, allowing more high-salinity water to move northward and enter the Irminger and Labrador seas.

5 Comparison Between 1987-90 and 2004-10



Comparision of Davis Strait volume and freshwater transports between 1987-90 (red bars) and 2004-10 (blue bars) using similar objective analysis procedures. Net central strait volume and freshwater transports have decreased in the recent period. Previous 1987-90 transport estimates from Cuny et al. (2005)** are also shown (yellow bars). The 2004-10 array includes measurements in the upper 150 m and over both shelves, which the 1987-90 moored array lacked, decreasing uncertainties.

7 Summary

Davis Strait is a significant Arctic gateway with transports similar in magnitude to Fram Strait.

Davis Strait 2004-10 transports have significant interannual variability with no clear trends.

Freshwater transport is dominated by velocity variations.

Changes in Arctic circulation and the strength of the subpolar gyre likely contributed to the differences in Davis Strait transports between 1987-90 and 2004-10.

Variations in the large-scale Arctic Oscillation phases between 1987-90 and 2004-10, from a more positive phase to a more negative phase, likely reduced southward transport of Arctic Water.

Weakening of the subpolar gyre since the late 1980s likely increased northward transport of West Greenland Irminger Water.

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Acknowledgements

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