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Baffin Bay Heat and Freshwater Contents and Transports from a suite of numerical modelling experiments

Nathan Grivault and Paul G. Myers
grivault@ualberta.ca pmyers@ualberta.ca
Department of Earth and Atmospheric Sciences
University of Alberta, Edmonton, Canada

Background and Aim

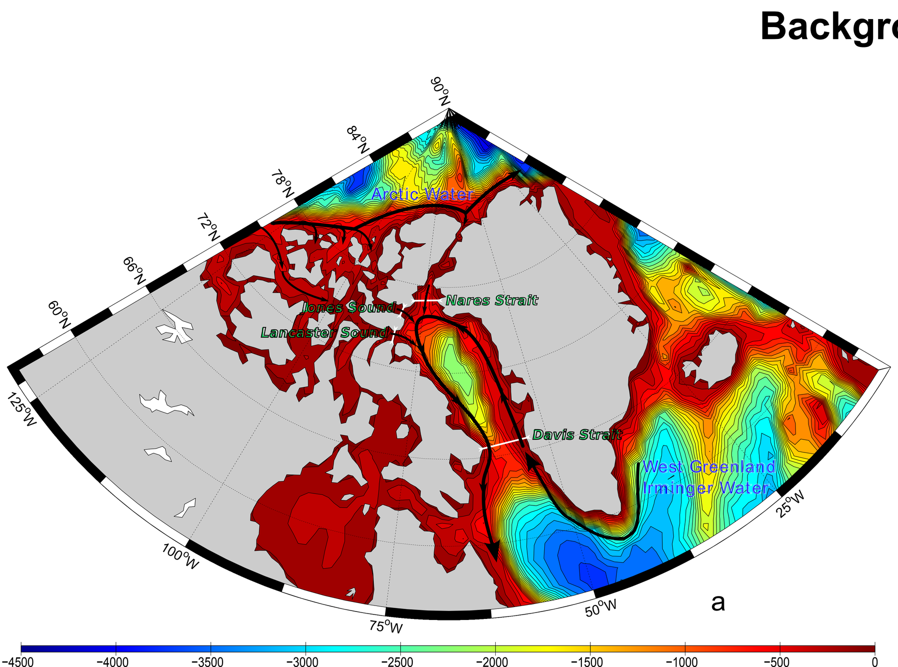

Fig. 1. Map of the Canadian Arctic Archipelago showing the location of Baffin Bay, the bottom topography (colour contours) and a schematic of the circulation in the region. The whitelines show the sections we use to define Baffin Bay for our content and transport calculations.

Baffin Bay is a crucial basin where waters from various sources are mixed. It is also a pathway for Arctic Water from the Arctic Ocean to the North Atlantic. An increase of heat in Baffin Bay may have acted as a trigger for accelerated melting of tide water glaciers in West Greenland (e.g. Holland et al., 2008). Changes in heat and freshwater content within the basin may also impact the basin's dynamic height, and thus the strength of the exchanges through the Canadian Arctic Archipelago and Davis Strait. Here we use a suite of numerical model experiments to examine these questions.

We looked at:

- Three sources of incoming water
  - Arctic Water
    Temperature < 1°C ; Salinity < 33.7 g/kg
  - West Greenland Irminger Water
    Temperature > 2°C ; Salinity > 34.1 g/kg
  - West Greenland Slope Water
    Temperature < 7°C ; Salinity < 34.1 g/kg
- One water mass from mixing
  - Transitional Water
    Temperature < 2°C ; Salinity > 33.7 g/kg

We used:

- Five different runs
  - Three configurations
  - Two resolutions
  - Four forcings

Run	Pan Arctic	Pan Arctic Climatic	Global	Arctic and North Atlantic	
Line color	blue	green	red	cyan	magenta
Grid resolution	1/4°	1/4°	1/4°	1/4°	1/12°
Integration period	1970-2007	1970-2100	1958-2004	2002-2009	2002-2010
Atmospheric forcing	CORE	IPCC	DFS4	CORE2	CGRF

Tab. 1. Details on the NEMO model (coupled to the LIM2 sea ice model) simulations used in this presentation. The given line colour is used to indicate fields for the given run in all subsequent figures.

Heat Content

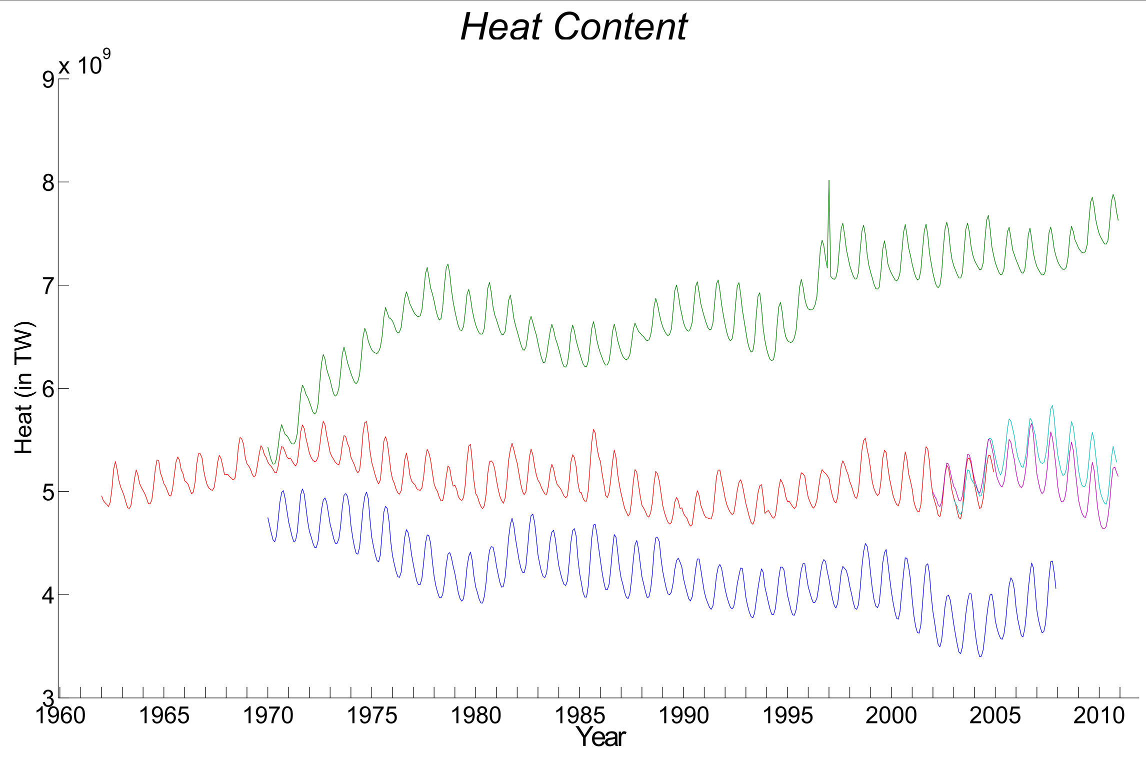

Fig. 2. Heat content for Baffin Bay (relative to a reference of -2°C) for 5 NEMO modelling experiments (table 1).

$$H_B = H_C + HT_{in} - HT_{out} \ (+ HF_S)$$
$$FW_B = FW_C + FW_{in} - FWT_{out} \ (+ FWF_S)$$

- H_C = Heat Content
- HT_{in} = Heat incoming Transport
- HT_{out} = Heat outgoing Transport
- HF_S = Surface Heat flux (not considered)
- FW_C = Freshwater Content
- FWT_{in} = Freshwater incoming Transport
- FWT_{out} = Freshwater outgoing Transport
- FWF_S= Surface Freshwater flux (not considered)

- Results are monthly averaged

Freshwater Content

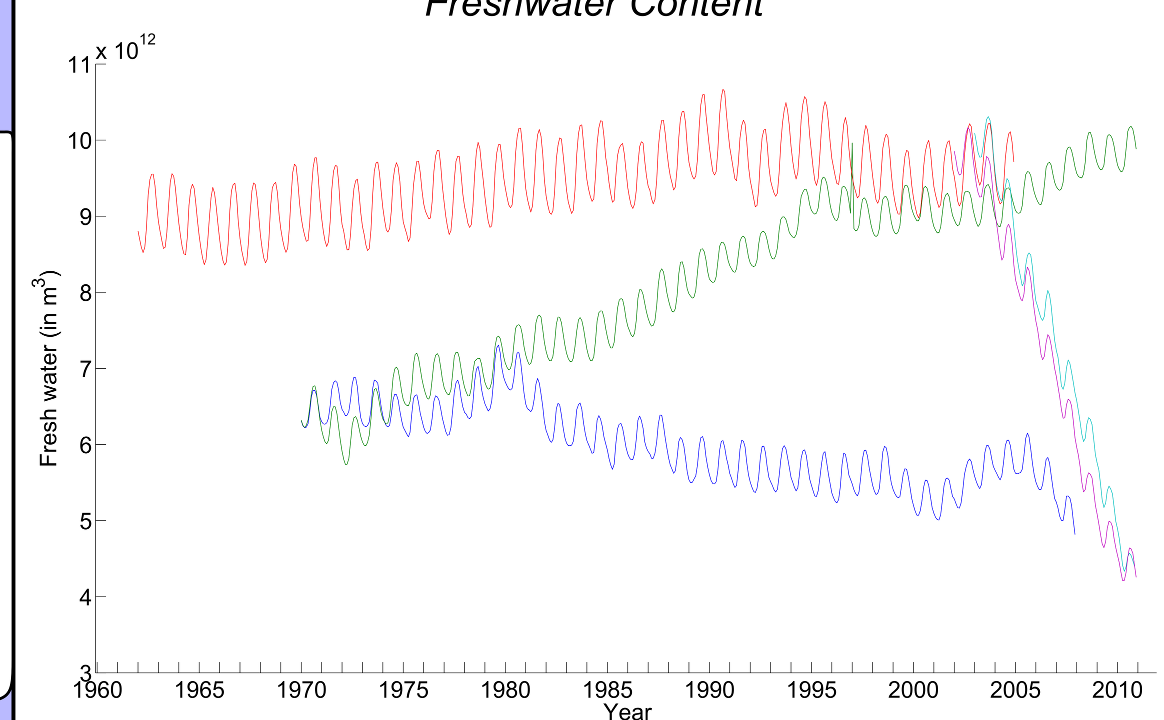

Fig. 3. Freshwater content (relative to a reference of 34.8 g/kg) for Baffin Bay for 5 NEMO modelling experiments (table 1).

Analysis

- Heat content
  - Differences don't seem to simply be a difference of resolution and forcing
  - Warming seen in the 1990s (except in the CORE forced Pan-Arctic), most pronounced in the IPCC run which has a spilke in 1997 (the year of observed acceleration at Jakobshavn Isbrae), which is driven by changes in WGIW (figure 4)
- Freshwater content
  - No consistency between experiments
  - Recent regional experiment undergoing significant drift, with strong reductions in freshwater content
- Heat transport
  - Heat import throught Davis Strait strongest in summer
  - Episodic heat import throught Nares Strait section
- Freshwater transport
  - Freshwater transport through Lancaster Sound and Davis Strait decreases in the 2000s in all experiments
  - Freshwater transport strongest in summer for all sections and experiments

Heat Content for each Water Masses

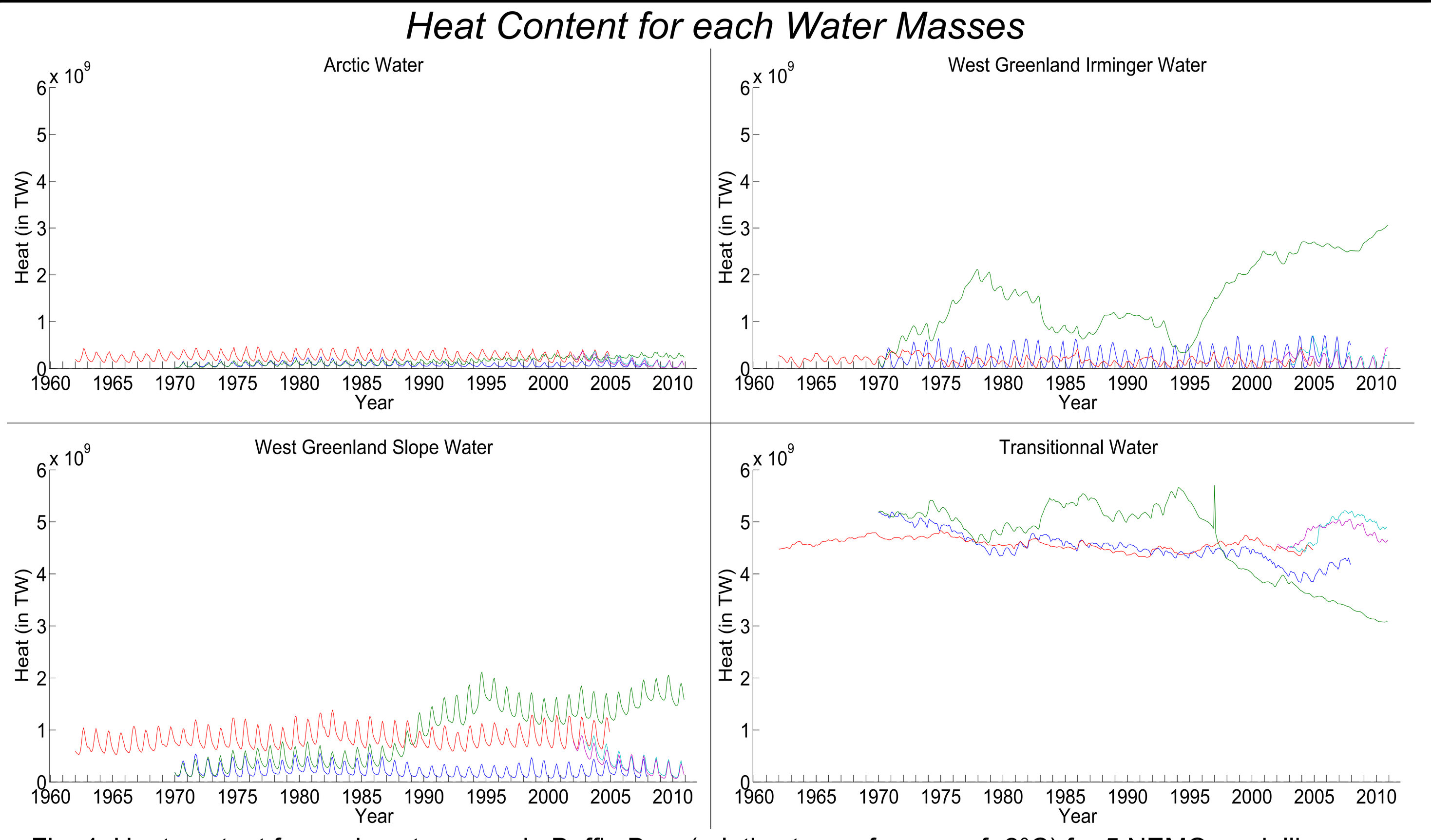

Fig. 4. Heat content for each water mass in Baffin Bay (relative to a reference of -2°C) for 5 NEMO modelling experiments (table 1)

Freshwater Content for each Water Masses

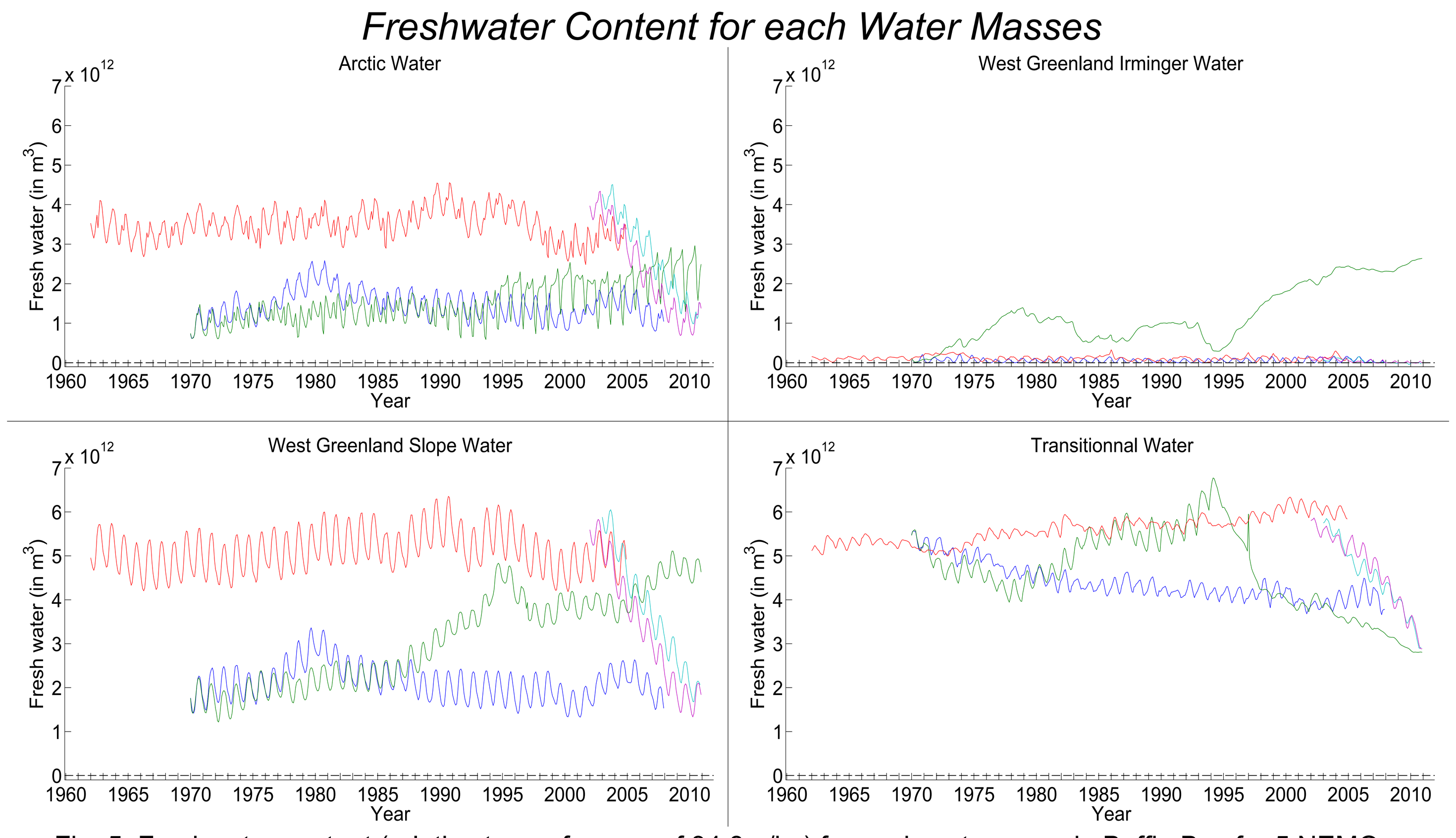

Fig. 5. Freshwater content (relative to a reference of 34.8 g/kg) for each water mass in Baffin Bay for 5 NEMO modelling experiments (table 1).

Impact on the Dynamic Height

$$DH_T \cong \left\langle \frac{1}{\rho^2_{(T_{ref},S_{ref},P)} c_p} \frac{\partial \rho}{\partial T} \right\rangle_z \int_{1000m}^{0} \rho_{(T_{ref},S_{ref},P)} (T_{ref} - T)\, dz$$

$$DH_S \cong \left\langle \frac{S_{ref}}{\rho_{(T_{ref},S_{ref},P)}} \frac{\partial \rho}{\partial S} \right\rangle_z \int_{1000m}^{0} \rho_{(T_{ref},S_{ref},P)} \frac{S_{ref} - S}{S_{ref}}\, dz$$

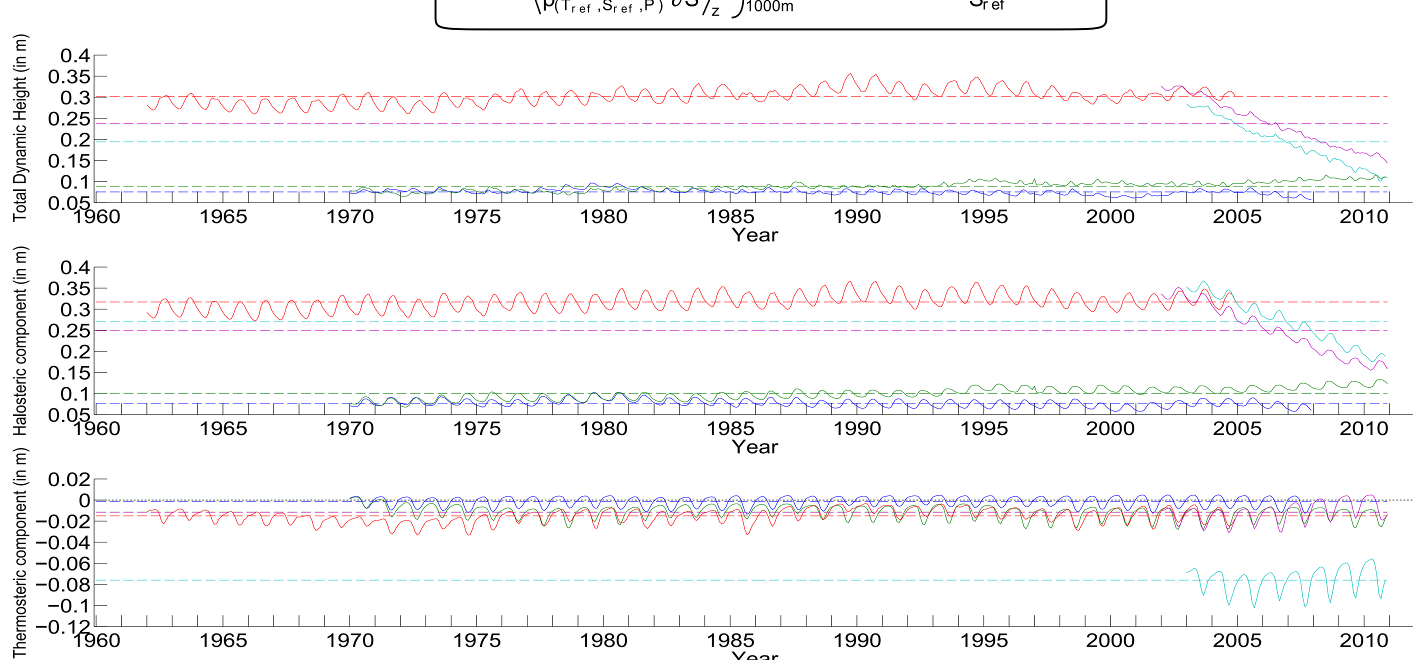

Fig. 6. Mean Dynamic Height integrated over the 1000 first meters in Baffin Bay.

Heat and Freshwater Transports

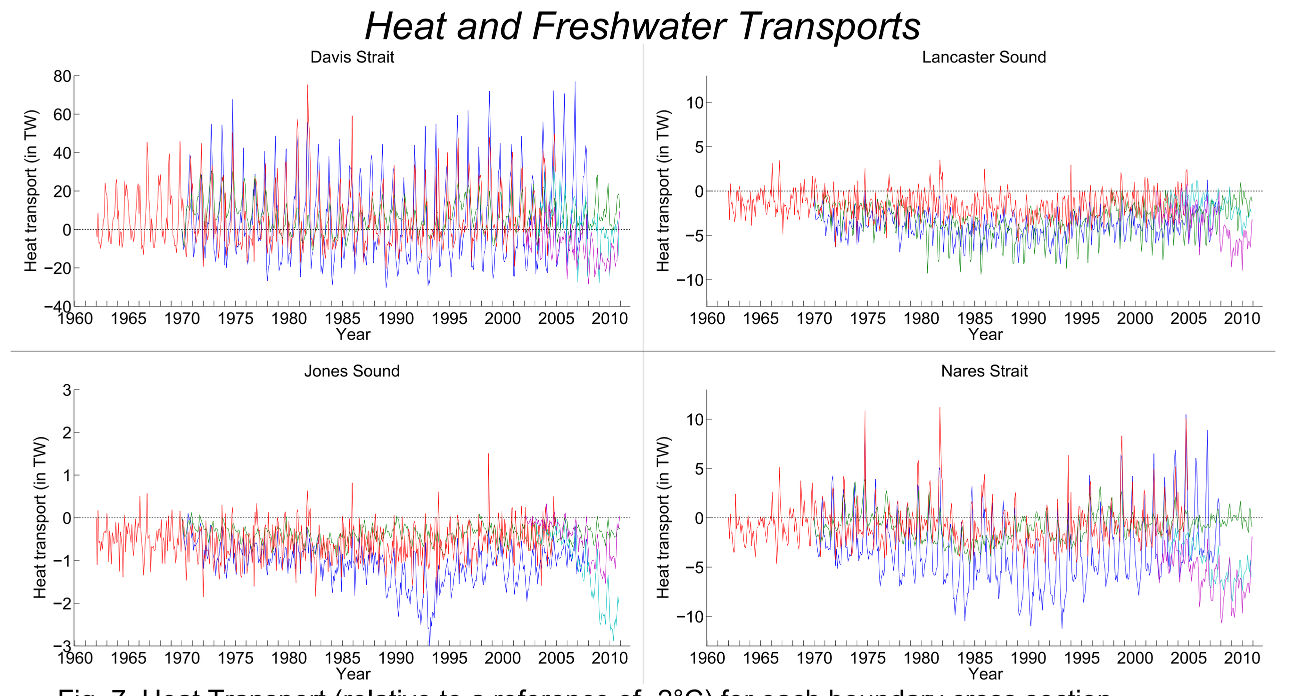

Fig. 7. Heat Transport (relative to a reference of -2°C) for each boundary cross section. Negative when going southward.

	Pan Arctic	Pan Arctic Climatic	Global	Arctic and North Atlantic	
Davis Strait	5.11 TW	6.76 TW	5.81 TW	2.56 TW	-8.47 TW
Lancaster Sound	-3.93 TW	-3.23 TW	-1.52 TW	-1.54 TW	-3.64 TW
Jones Sound	-1.06 TW	-0.39 TW	-0.56 TW	-1.08 TW	-0.43 TW
Nares Strait	-3.27 TW	-0.85 TW	-0.68 TW	-4.35 TW	-5.64 TW

Tab. 2. Mean heat transport (relative to a reference of -2°C) for each sections and runs

	Pan Arctic	Pan Arctic Climatic	Global	Arctic and North Atlantic	
Davis Strait	-113.37 mSv	-48.59 mSv	-63.53 mSv	-104.17 mSv	-85.44 mSv
Lancaster Sound	-90.77 mSv	-44.83 mSv	-43.78 mSv	-54.63 mSv	-46.46 mSv
Jones Sound	-10.66 mSv	-4.02 mSv	-8.91 mSv	-8.84 mSv	-2.69 mSv
Nares Strait	-14.06 mSv	-4.07 mSv	-15.83 mSv	-21.68 mSv	-20.47 mSv

Tab. 3. Mean freshwater transport (relative to a reference of 34.8 g/kg) for each sections and runs

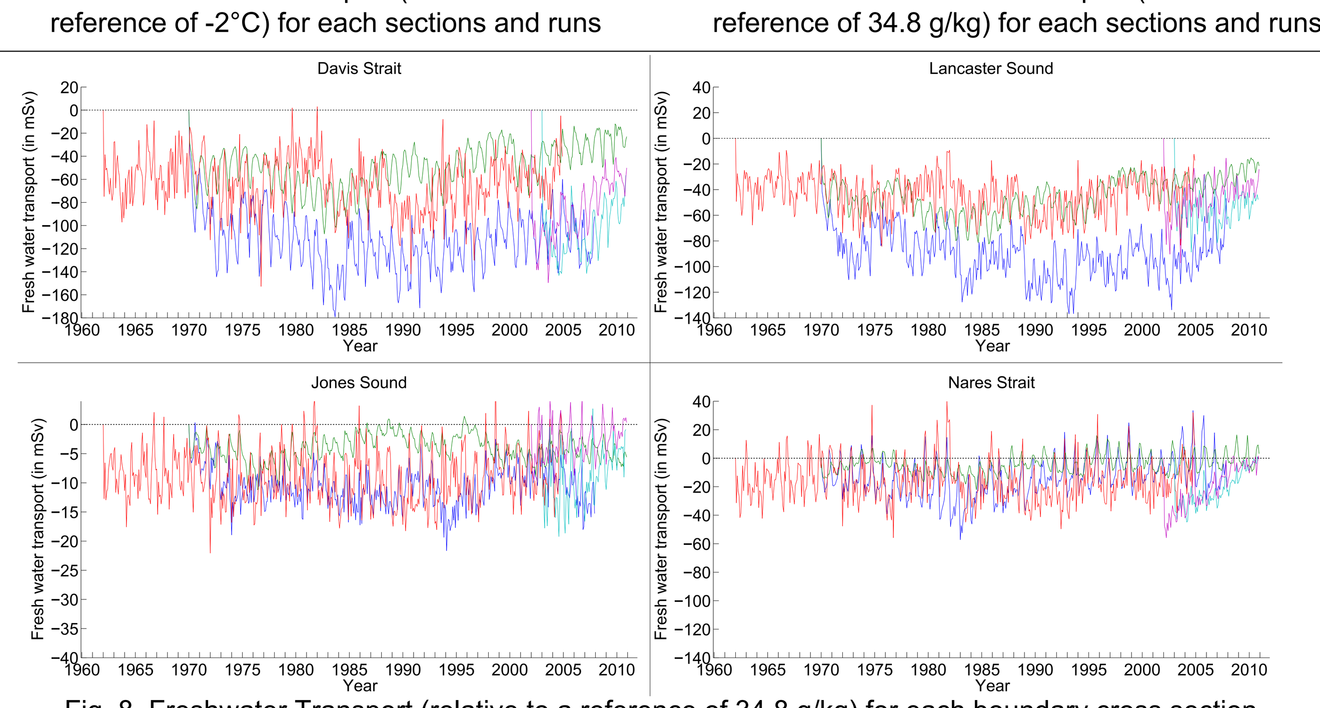

Fig. 8. Freshwater Transport (relative to a reference of 34.8 g/kg) for each boundary cross section. Negative when going southward.

Preleminary conclusions

- Increase of heat:
  - From an increase of heat import and a reduction of heat export
  - Impact on sea ice melting?
- Decrease of fresh water:
  - Decrease in both import and export
  - Reduction of the sea height gradient between the Arctic Ocean and North Atlantic
  - Reduction of currents velocity from Arctic Ocean to North Atlantic?

NSERC CRSNG

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