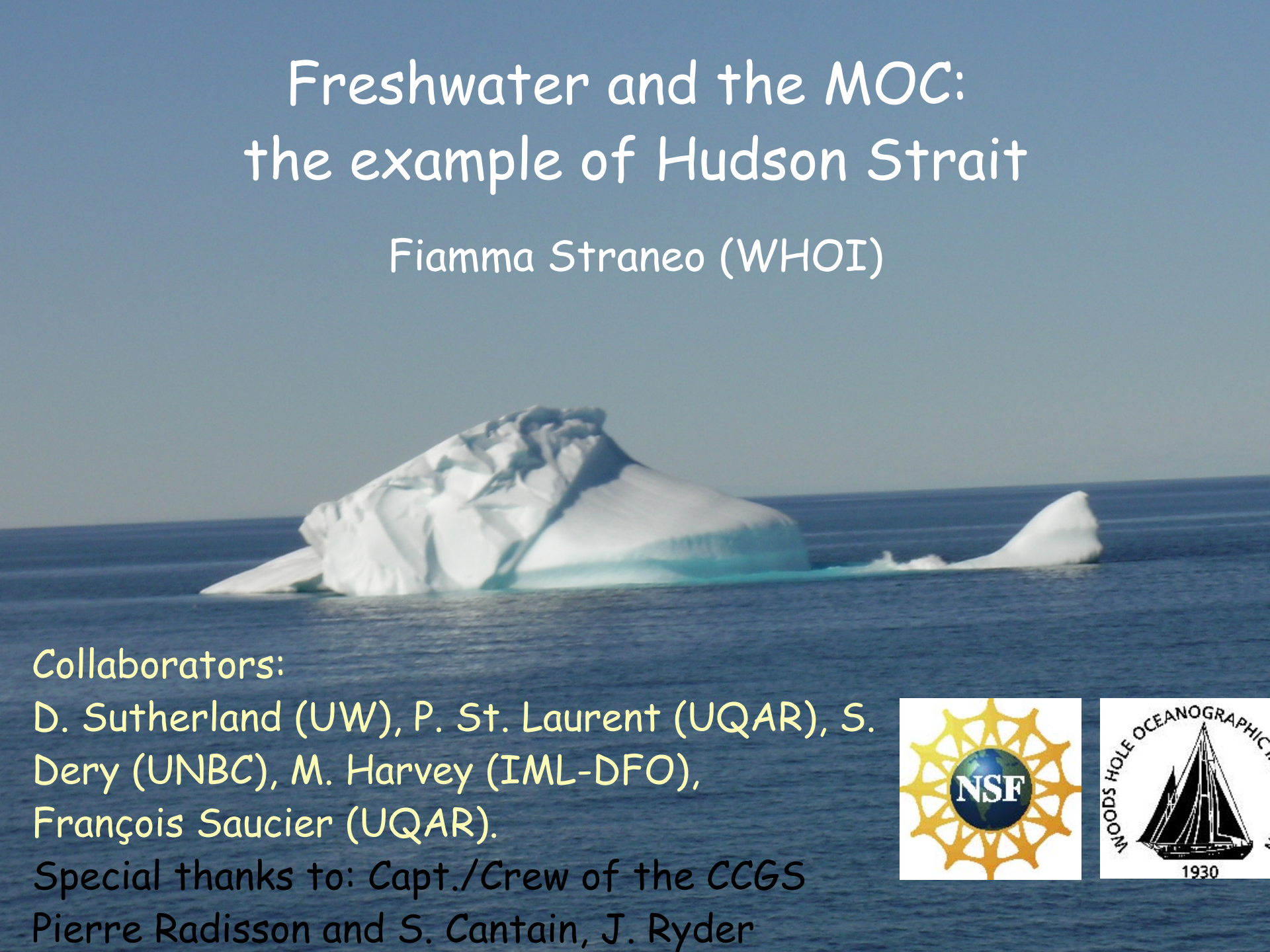
Freshwater and the MOC: the example of Hudson Strait

Fiamma Straneo (WHOI)



Collaborators:
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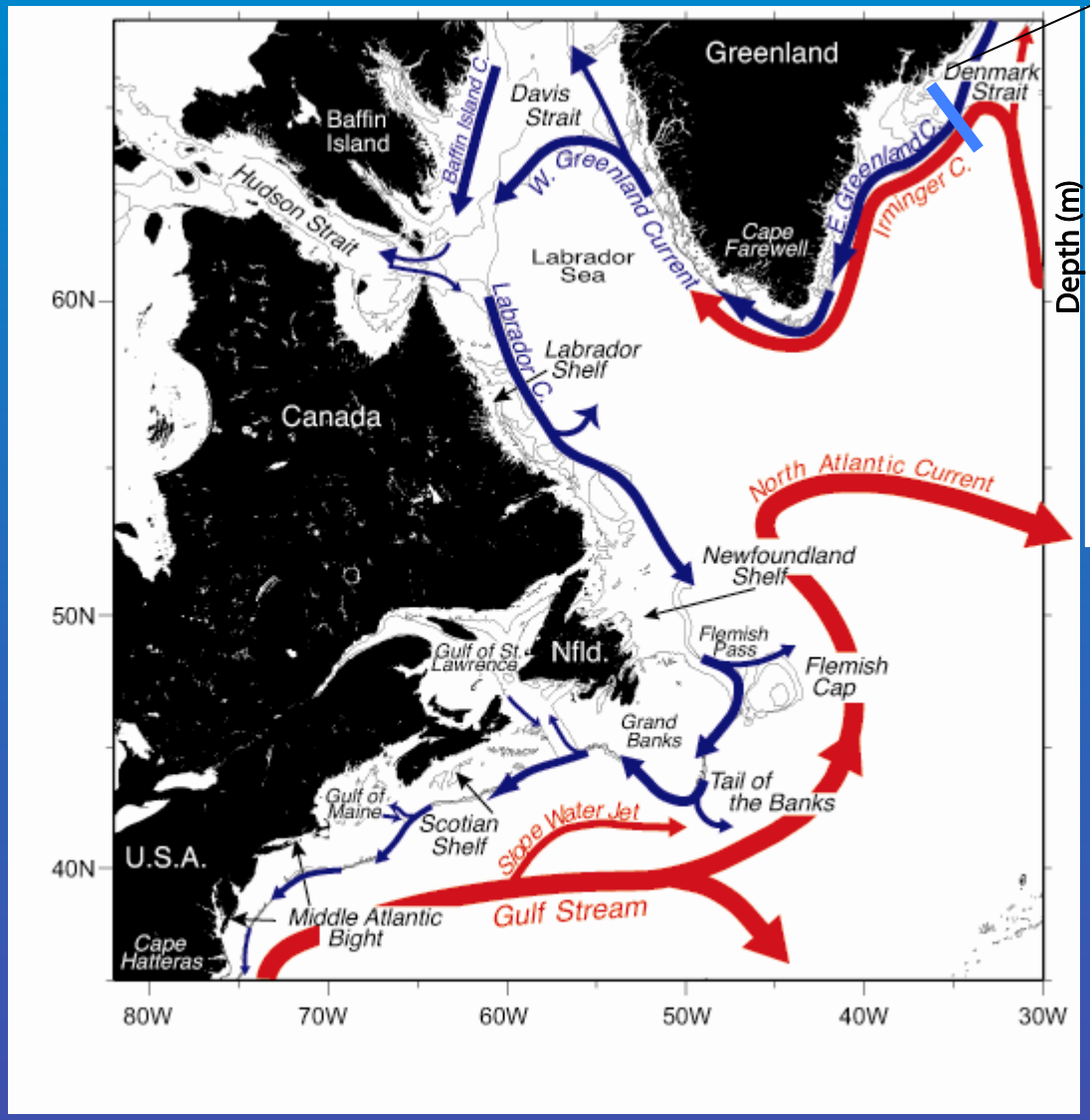
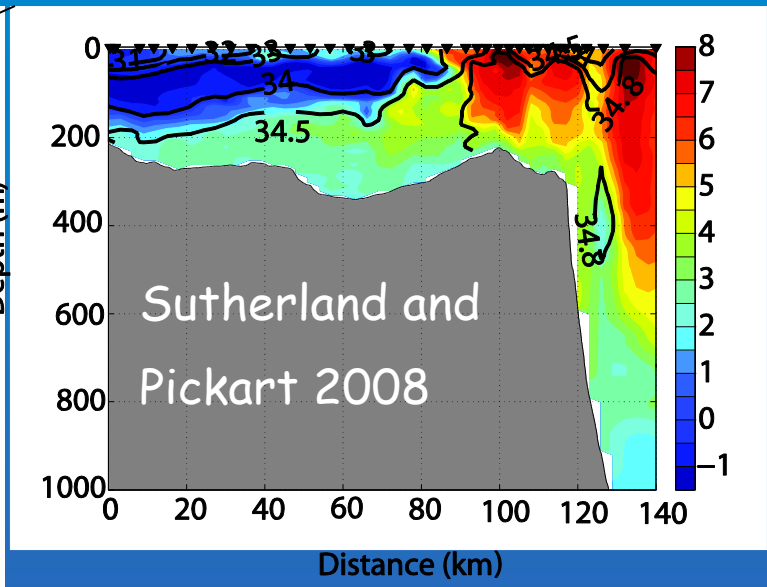
Special thanks to: Capt./Crew of the CCGS Pierre Radisson and S. Cantain, J. Ryder

Freshwater carried by narrow, shelf bound currents

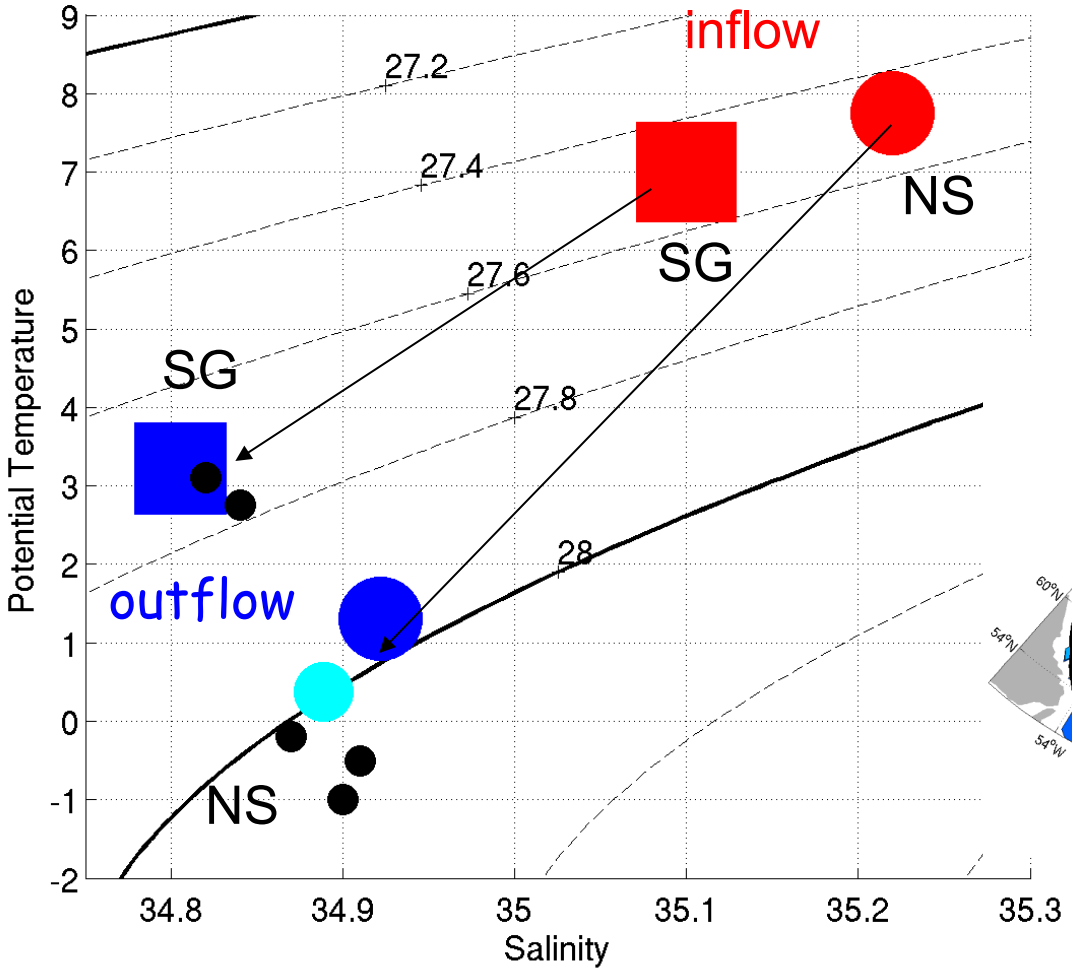


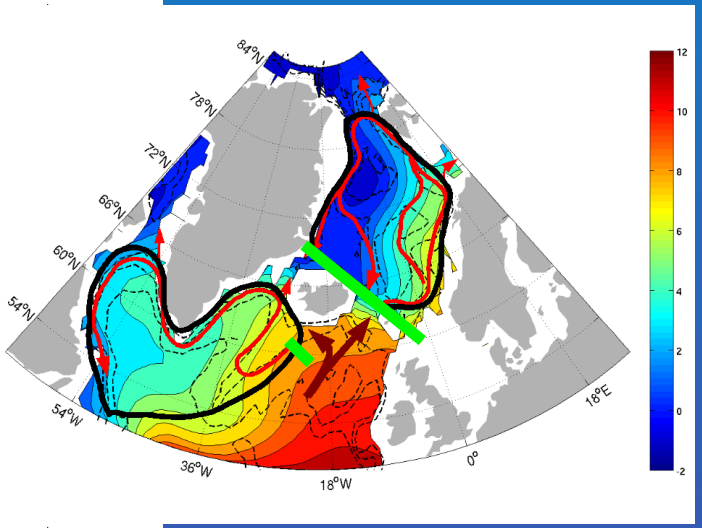


Courtesy of:

P. Fratantoni & R. Pickart 2007;

Freshwater is an important element of DWF

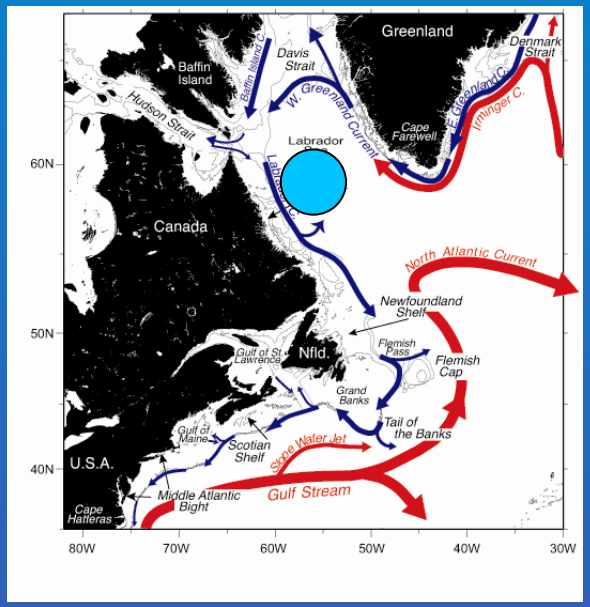


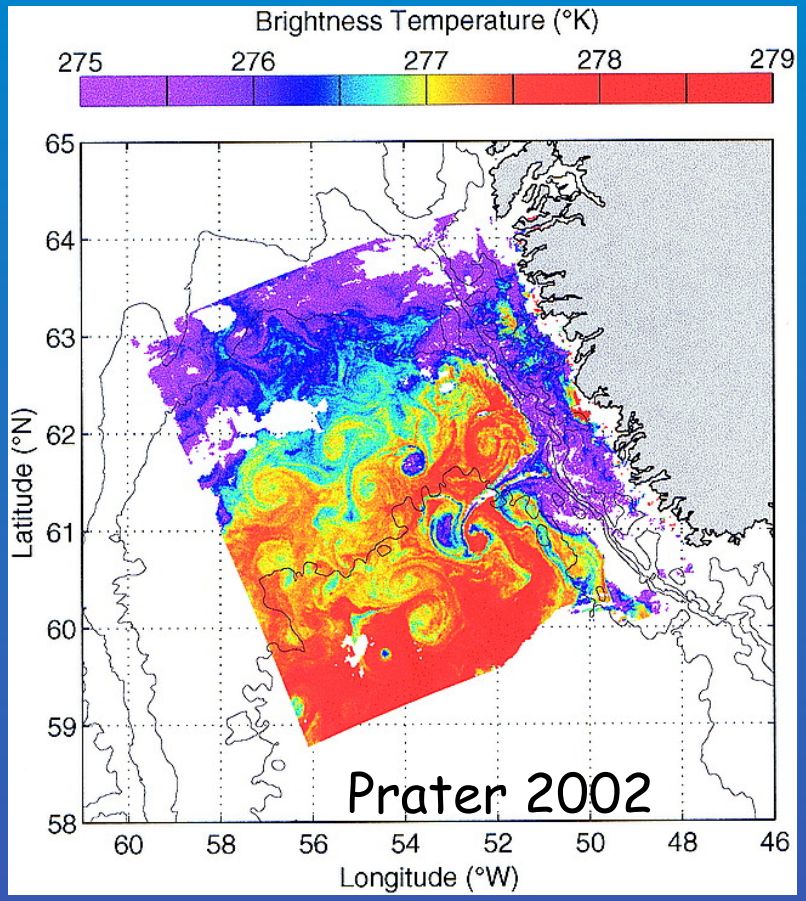


van Aken and Becker 1996; Pickart et al. 2005; Hansen and Østerhus 2000, Pickart a
Spall 2007; Kieke et al. 2007, Lazier 1980, Eldevik et al. 2008; Schott and Brandt 20

Spreading of freshwater to interior regions

Dominant mechanism: boundary current instability





From which side?

West: Myers et al. 2005; Schmidt and Send, 2007

East: Maslowski et al. 2009 (personal communication)

Freshwater, the MOC and its Variability

Step 1: Baseline (steady state)

i) Net freshwater inputs (precipitation /rivers)

ii) Freshwater pathways (freshwater E/W of Greenland)

iii) Mechanisms of freshwater spreading to the interior regions

→ Impact of mean MOC

Step 2: Variability

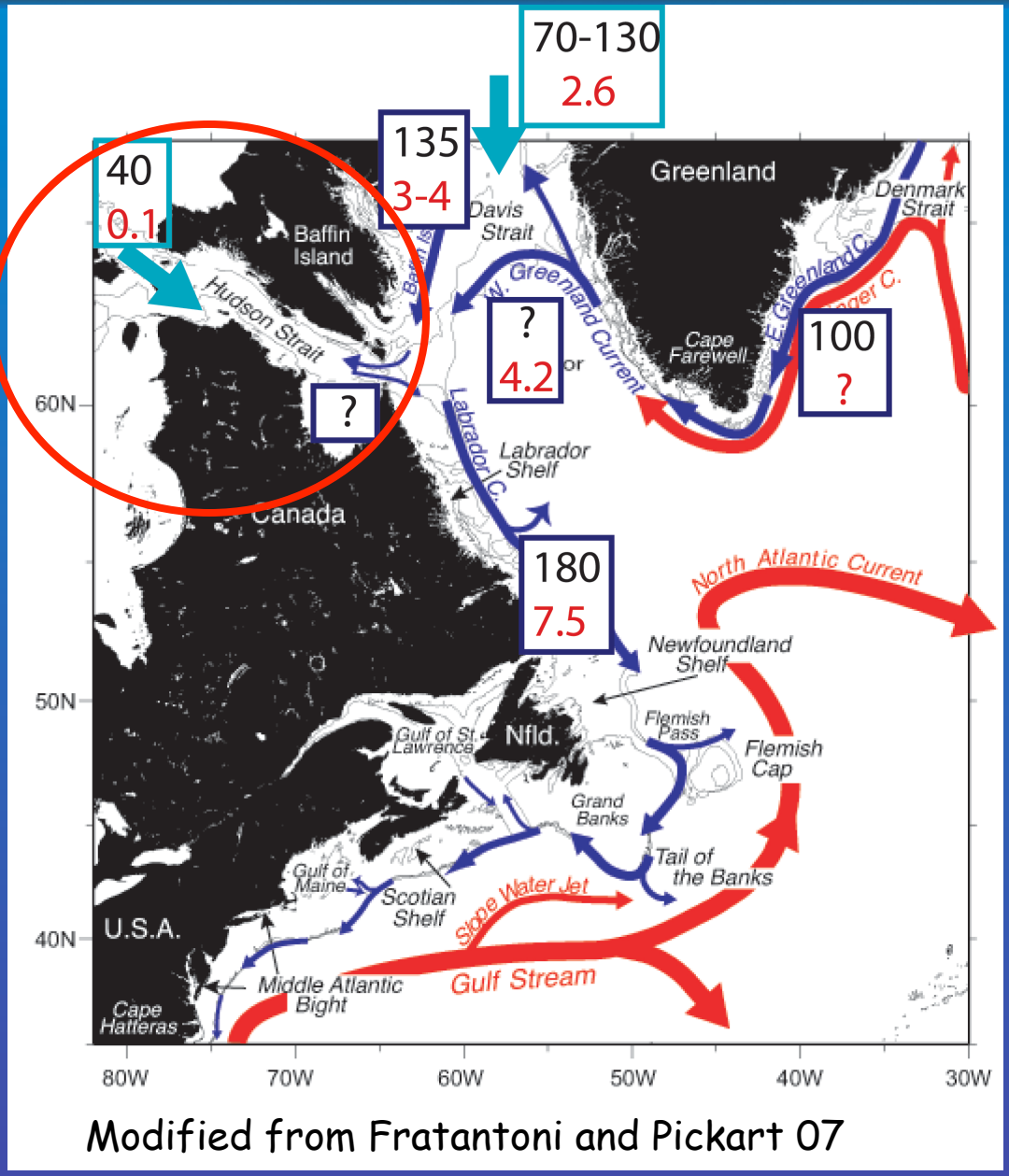
i) Changes in net inputs – Arctic and Greenland ice melt, fluctuations in P-E

ii) Changes in pathways (Arctic FW export alternates E/W of Greenland)

iii) Changes in interior -boundary current exchange (subpolar gyre strength or structure)

→ Impact on MOC variability

Step 1 – Establishing the baseline



Modified from Fratantoni and Pickart 07

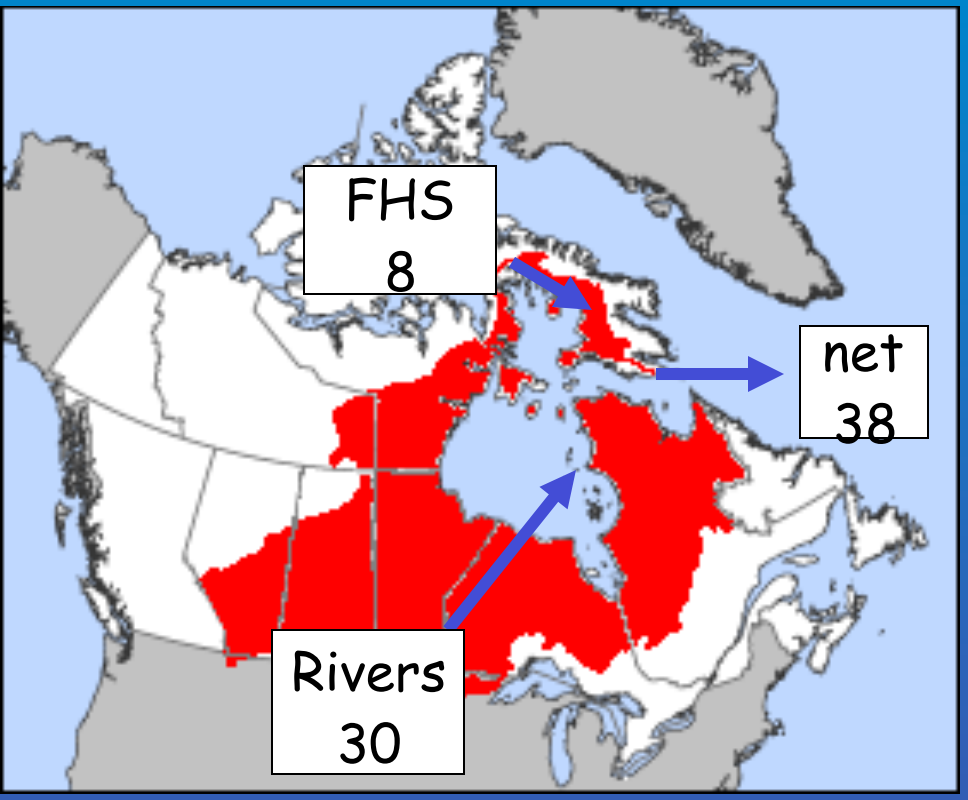
FW (mSv 34.8)
Volume (Sv)

Sources from

Dickson et al. 2007;
Loder et al. 1998; Cuny et al. 2002;

And ASOF Volume 2008

Freshwater input into the Hudson Bay System



(Straneo and Saucier 2007b)

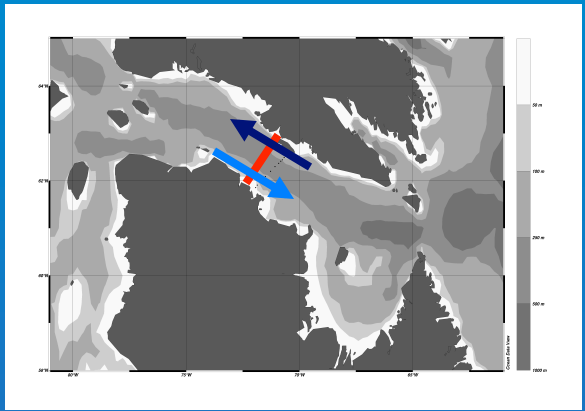
River Input ~ 900 km^3/yr

(Dery et al. 2005)

(Discharge into Arctic O. ~2500 km^3/yr)

(*McClelland et al. 2006*)

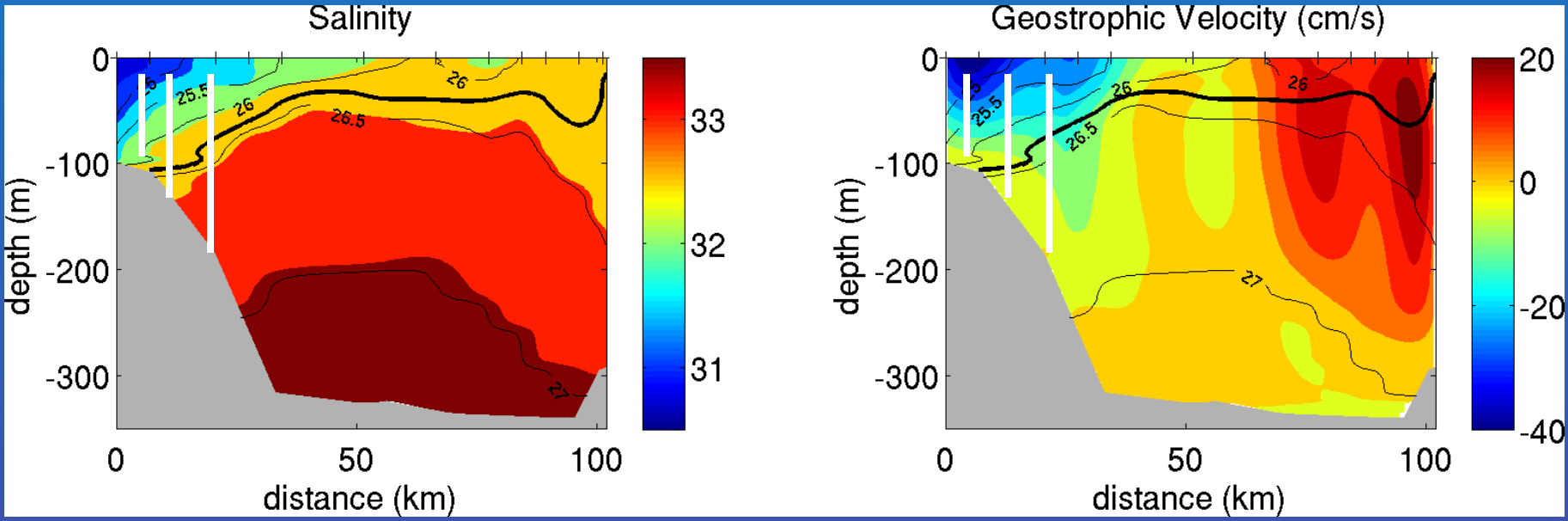
Measuring Freshwater Export via the Hudson Strait Outflow



Mooring array across the outflow

August 2004- August 2007

(joint US/Canadian effort)



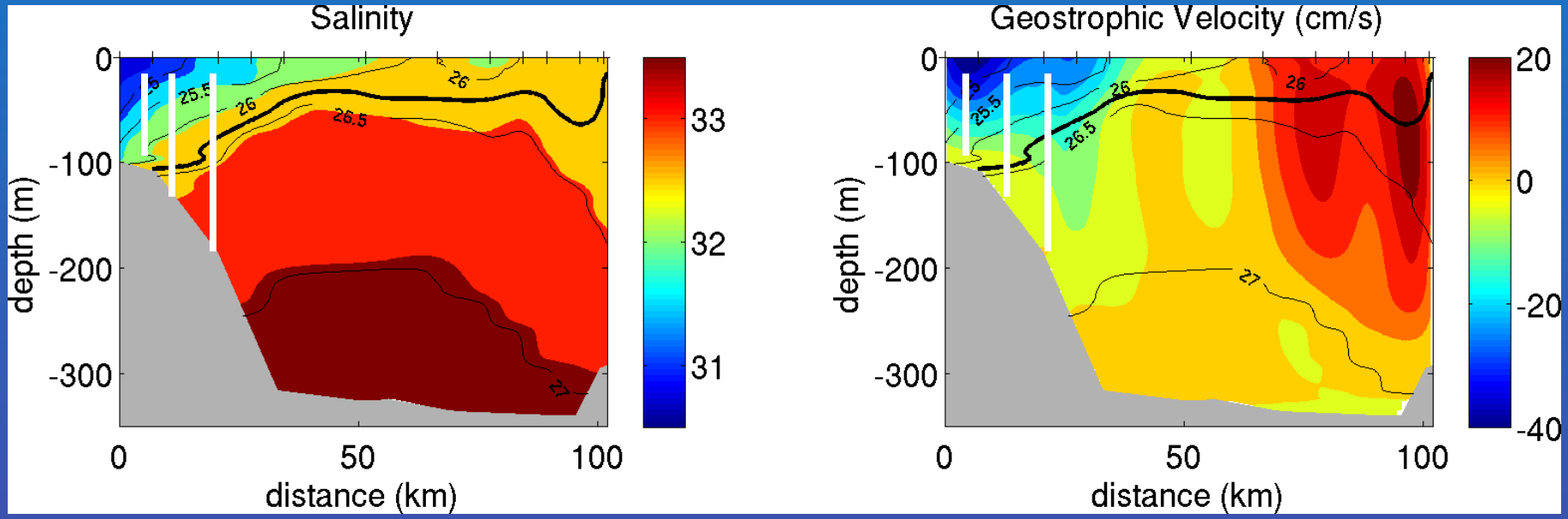
Measuring Freshwater Export via the Hudson Strait Outflow

Challenges:

-6-7 month ice-cover with considerable ice-ridging

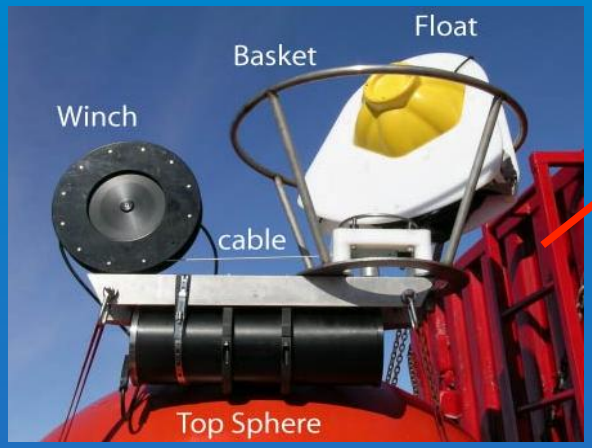
- drifting icebergs

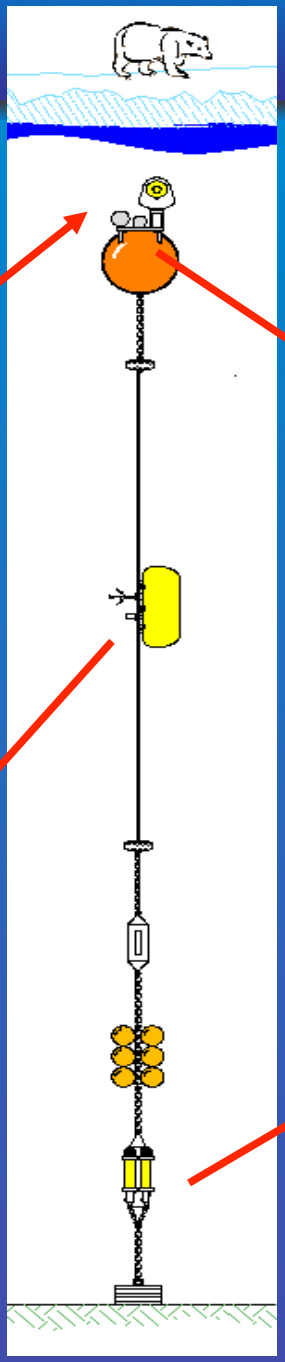
- large tides (8m range and currents 1m/s)



Profiling Mooring

Arctic Winch: T, S 0-50m



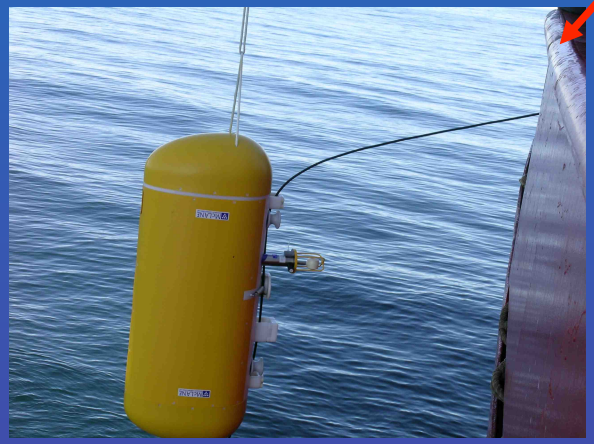


Upward Looking Sonar- IPS

ice-thickness and tilt

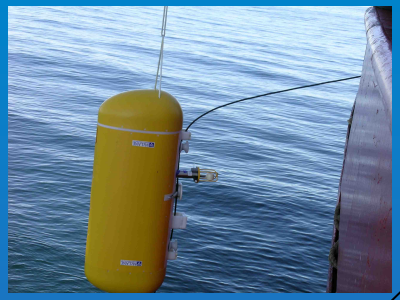
Moored Profiler

T, S 50-180m



Long Range 75kHz ADCP

1. Large Seasonal and subtidal variability in the outflow



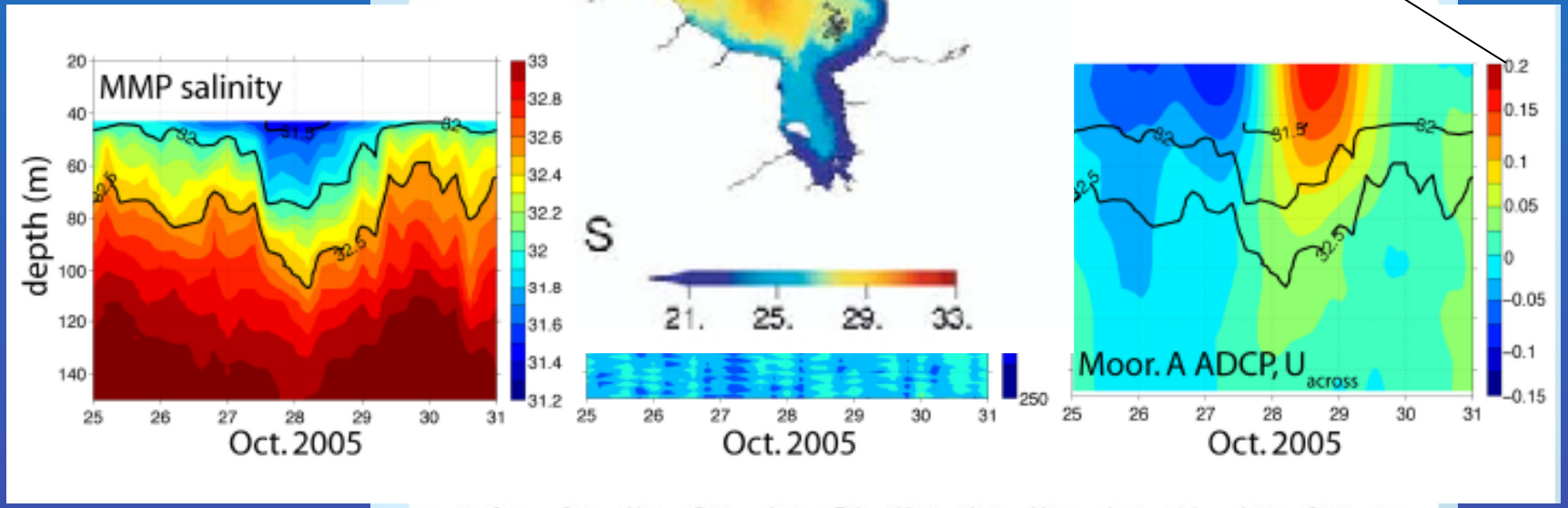
1. Large Seasonal and subtidal variability in the outflow

Seasonal Variability:

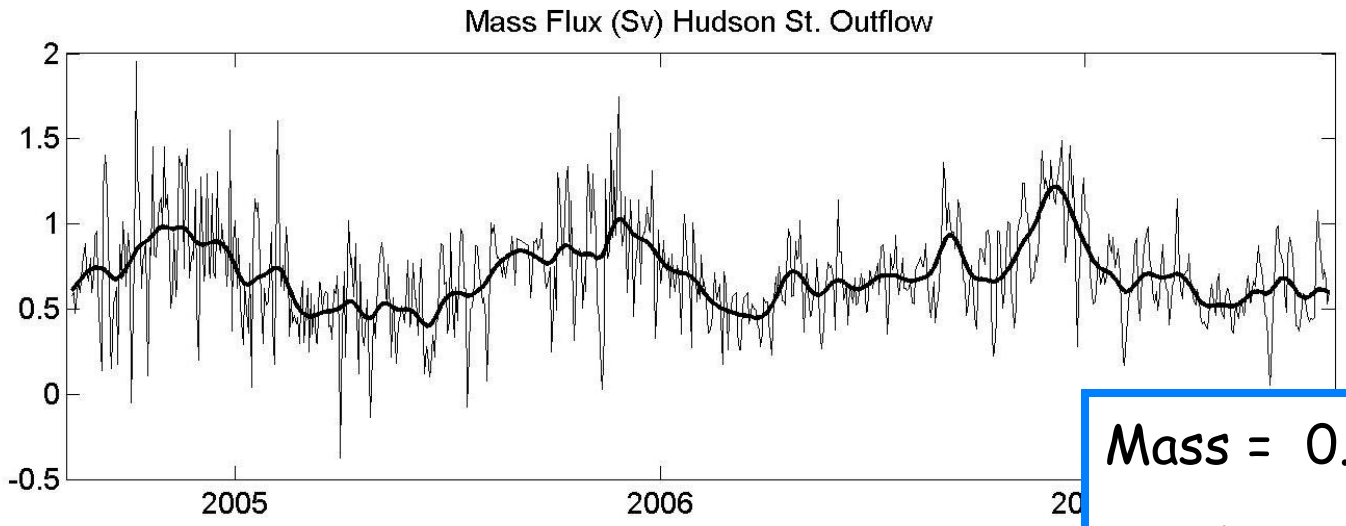
Sea-ice melt and river run-off

2-5 day variability:

wind fluctuations at the mouth of Hudson Bay



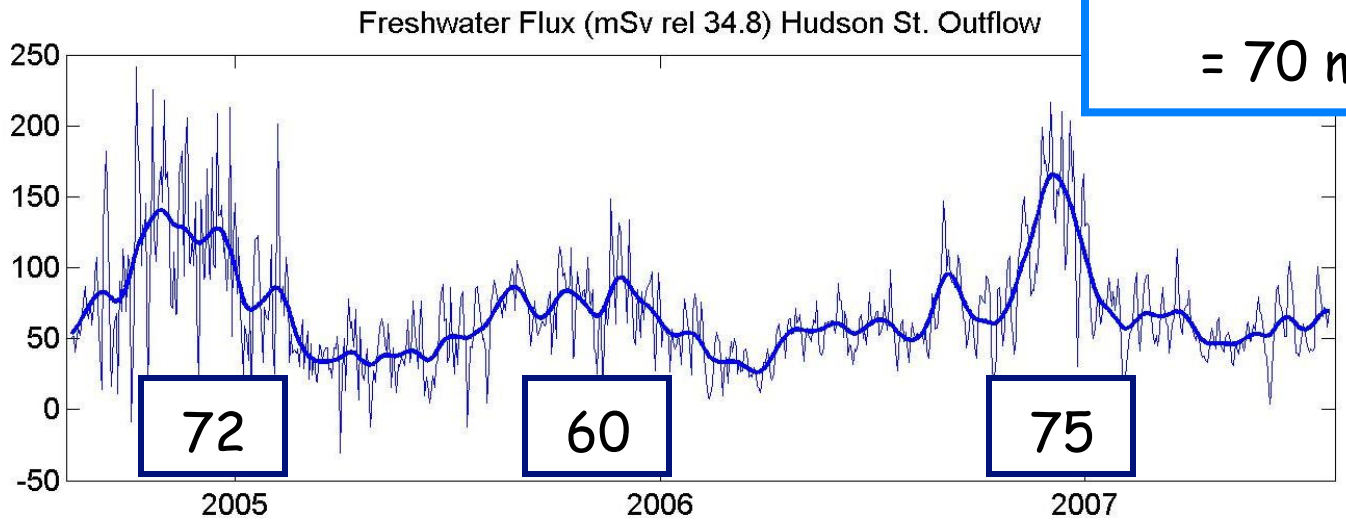
Mean Freshwater Flux from 2004-2007



Mass = 0.7 Sv

Freshwater (34.8)

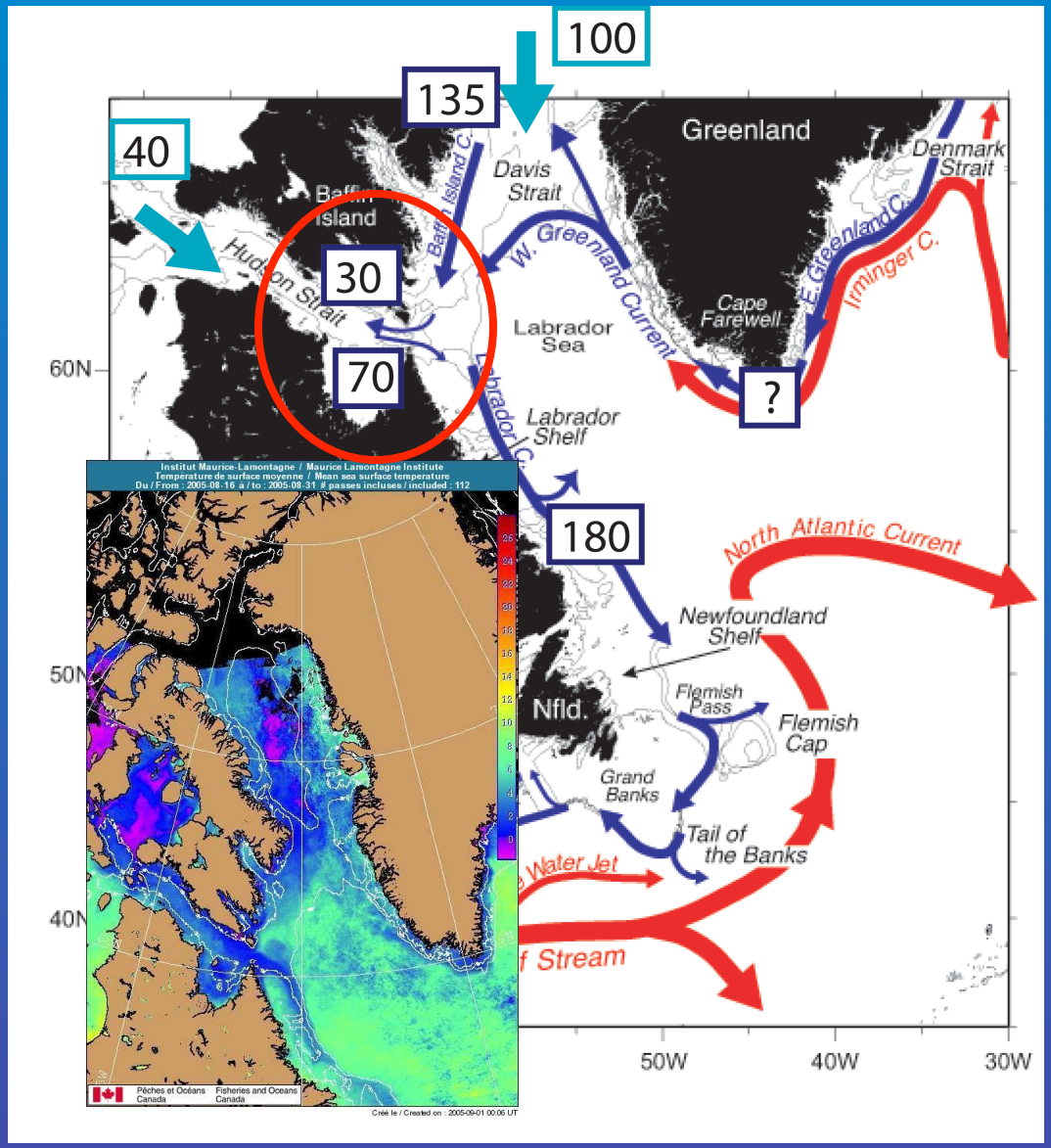
= 70 mSv



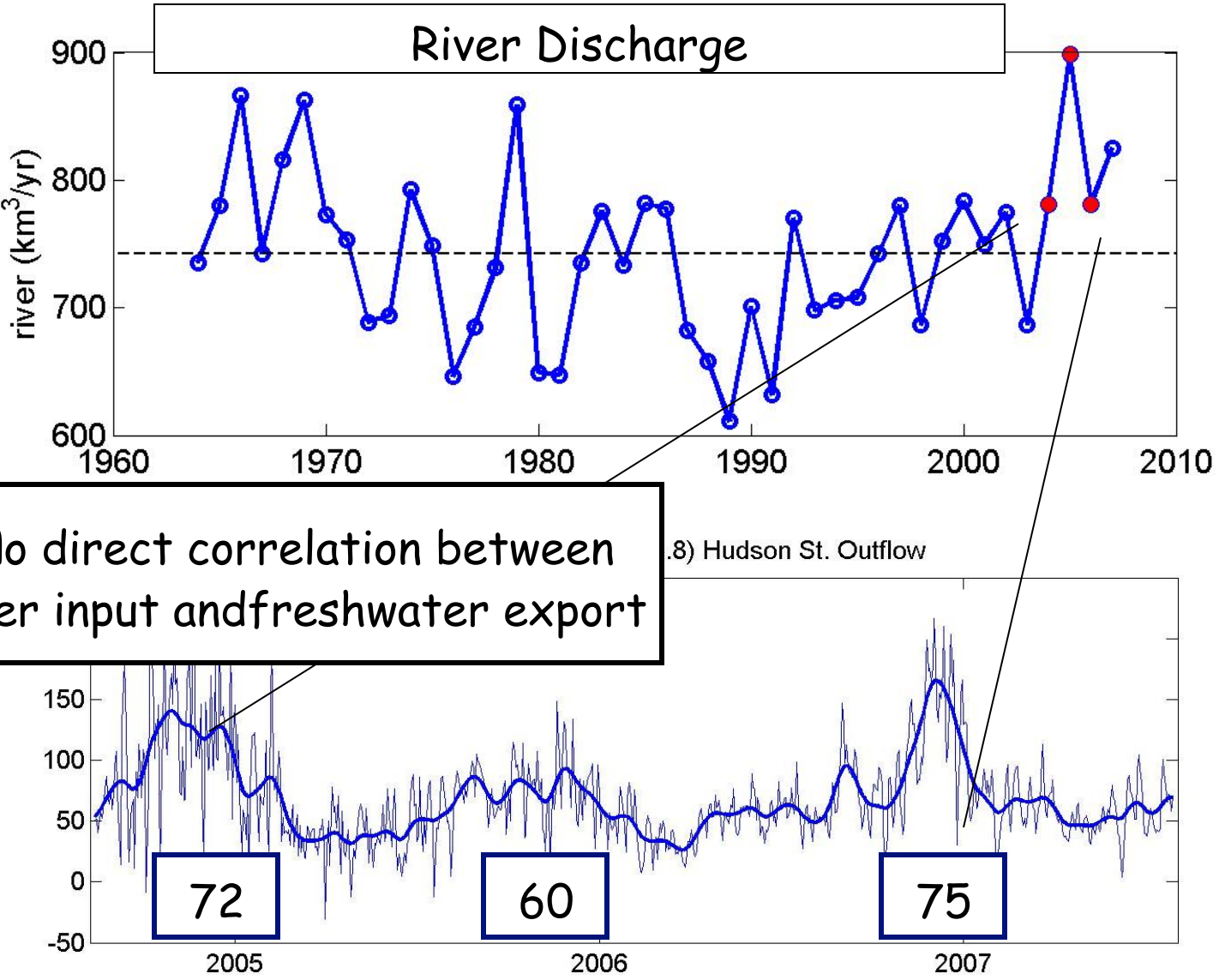
Freshwater Pathways through the Labrador Sea

1. *40% of the freshwater carried by the Labrador Current is coming from Hudson Strait*

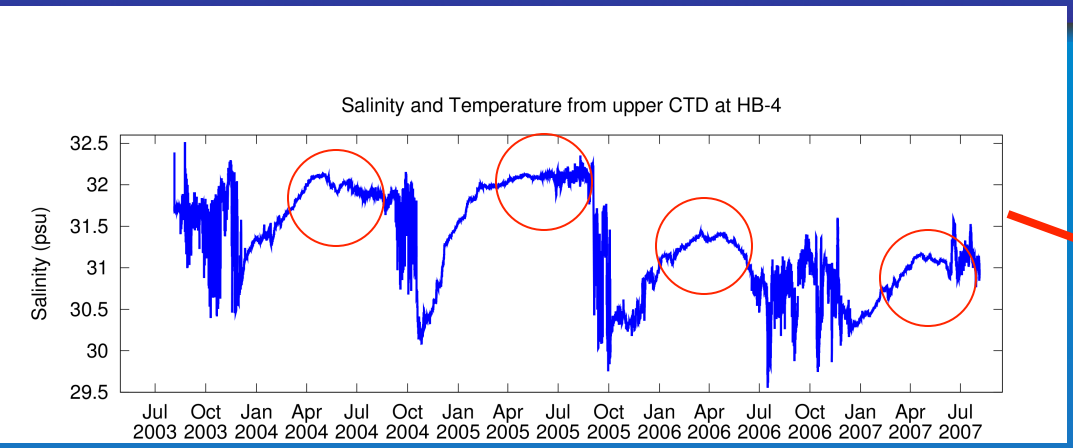
2. *~30 mSv of the freshwater from Davis Strait is re-cycled through the Hudson Bay System*
   → change in timing and character

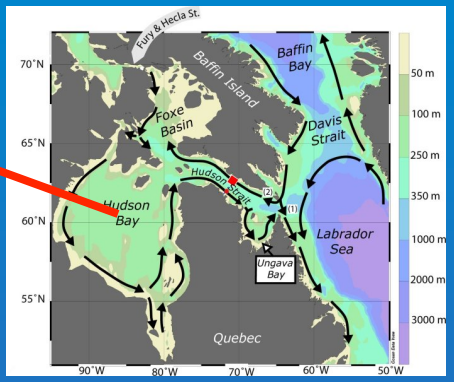


Interannual variability in the freshwater flux?



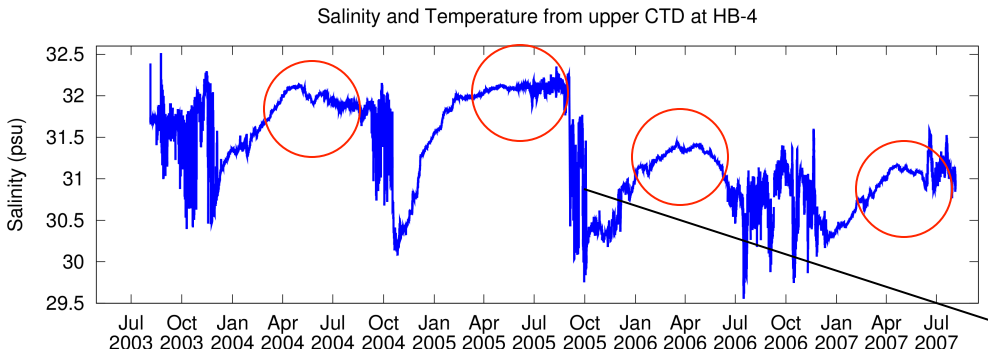
Freshwater Storage and Release by Hudson Bay

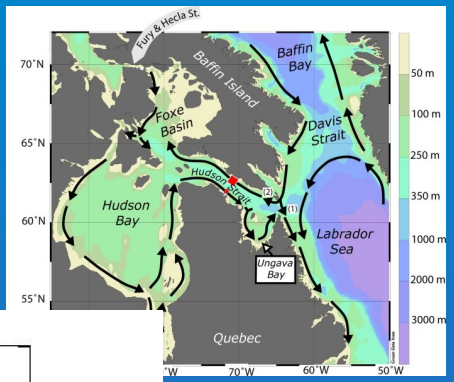


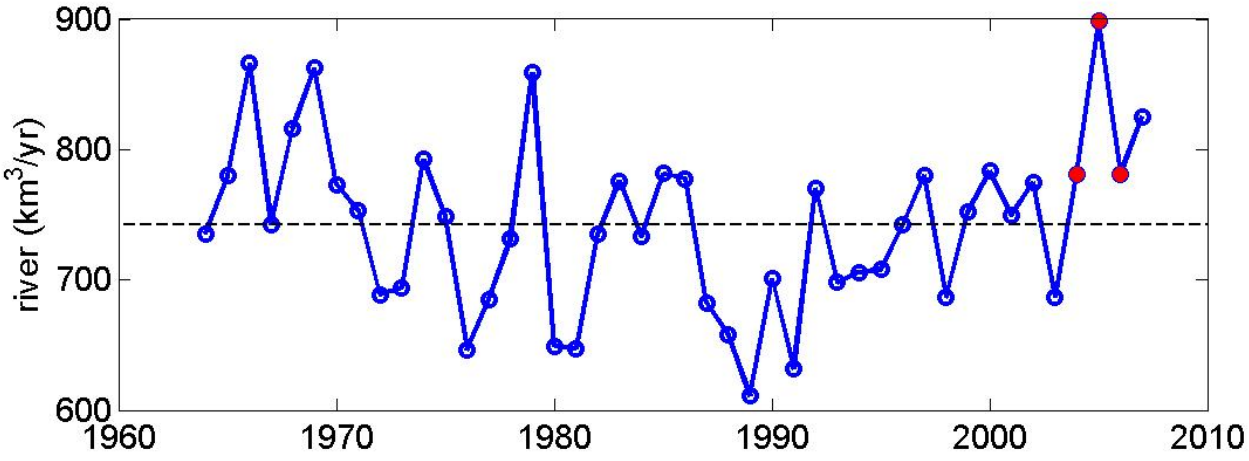


Halocline properties in Hudson Bay

Freshwater Storage and Release by Hudson Bay







Changes in river input → changes in freshwater content of Hudson Bay

How these changes are transmitted downstream depends on processes which regulate the freshwater storage/release in Hudson Bay.

(Hudson Bay stores 10,000 km^3 of freshwater relative to S = 34.8)

Conclusions – Hudson Strait Outflow

i. 40% of the Labrador Current's freshwater is fed by the Hudson Strait outflow (in part due to re-routing of Davis St. outflow)

ii. Large subtidal variability in the outflow → no synoptic monitoring

iii. Interannual changes cannot be simply attributed to variations in the hydrologic cycle but depend on Hudson Bay's storage and release mechanisms

Future Work:

A. Across strait (inflow + outflow) moorings will be recovered this summer

B. Outflow current has regular characteristics and can be monitored with limited resources

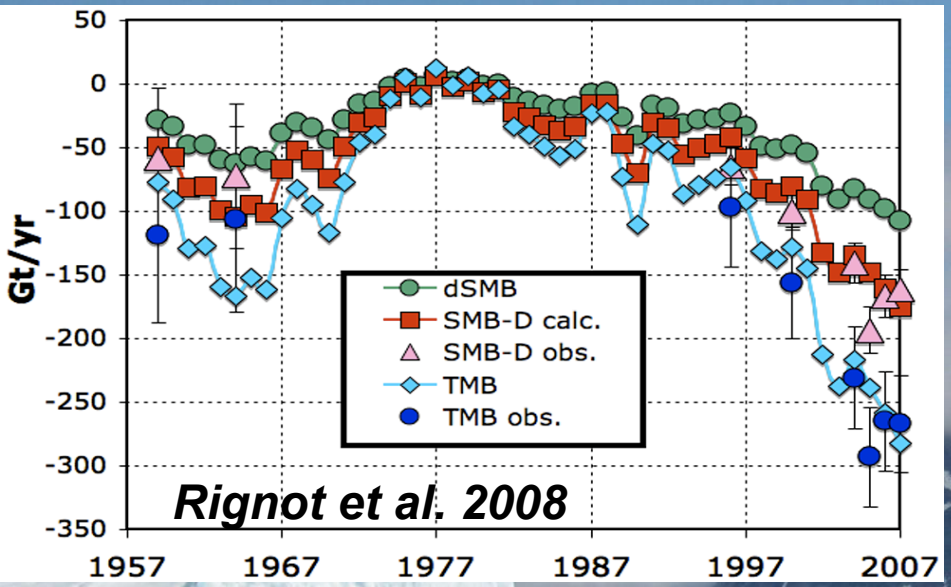
Summary

Freshwater is an integral component of the MOC and its changes are relevant for MOC variability – yet our knowledge of the net inputs, the pathways and the exchange mechanisms is still limited.

Freshwater inputs and pathways are intrinsically difficult to observe but we now have (some) tools and skill in making these measurements.

The large changes happening in the Arctic and Greenland will (eventually) be transmitted downstream – but the timing and their character will depend on processes controlling storage and release in the Arctic/Subarctic basins.

The Greenland Ice Sheet and the MOC



Greenland Ice Sheet has doubled its mass loss during the last decade due to changes in its outlet glaciers.

A growing body evidence points at warming of the subpolar N. Atlantic as the trigger for the mass loss.

Weakening and warming of the subpolar gyre → Increased freshwater discharge from GIS → MOC changes