FRESHWATER IN THE EAST GREENLAND CURRENT

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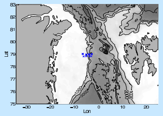
Introduction

The transport of fresh and cold polar water southward through Fram Strait within the East Greenland Current (EGC) is a major, if not the main, oceanic pathway of freshwater entering the North Atlantic. A freshwater layer can close down deep convection in the sub polar gyres and hence influence the meridional overturning cell, also known as the Global Conveyer Belt. Rapid climate change can therefore be triggered by large freshwater anomalies. For the understanding of global climate knowledge of the magnitude and variability of the freshwater transport is therefore indispensable.

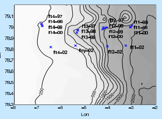
The Norwegian Polar Institute (NPI) has been making regular measurements in Fram Strait using moorings and hydrography since 1990. Starting in 2003 within the ASOF program, the focus is now on freshwater flux. In this poster we present a first estimate of the liquid fresh water flux from these data.

Data

Since 1990 NPI has monitored the EGC at about 79N using moored instruments. A continuous monitoring array of four moorings across the EGC have been in regular operation since fall 1997. During this years regular CTD surveys were also carried out. This poster focuses on the most recent data (2002-2003), and on the year of best mooring coverage (1999-2000), but work is in progress to analyze the whole data set.

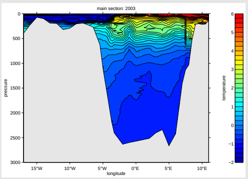


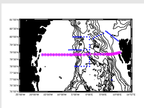
Study area and mooring positions (crosses). The numbers in mooring names indicate the year of deployment.

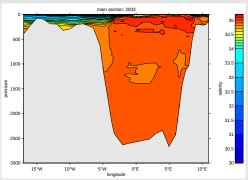


Hydrography

An extensive hydrographic survey was carried out in Fram Strait in September 2003. The main section across Fram Strait shows the cold and low salinity Polar Water on the East Greenland Shelf in the western part of the section. At the upper eastern part the warm and saline Atlantic Water flows northward into the Polar Ocean. After a journey through the Arctic, some of this water returns, transformed into colder and lower salinity Arctic Atlantic Water, which can be seen at the Greenland shelf break up to depths of about 1200m. The third water mass flowing south within the EGC is Atlantic Water which recirculates within Fram Strait, the rAW. Its characteristics are not as extreme as the inflowing AW, but is also characterized by high salinity and temperature, seen here at about 3W and 250m depth.







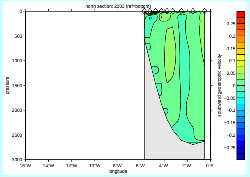
Temperature (upper figure) and salinity (lower figure) section across the Fram Strait. Positions of the used CTDs are marked as magenta circles in the map. The table gives the total geostrophic transports relative to the bottom. The mass compensated heat transport is 8.5TW into the Arctic ocean. Using only the Bering Strait salt inflow (0.8*34.5 to close the Arctic Freshwater Budget, the net outflow through Fram Strait amounts to 380 km^{3}year^{-1}.

Variable	Transports [2]
Mass	5.19
Salt	179.8
Freshwater[1]	1200

Geostrophic transports

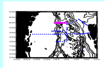
Mass transport in the ocean is mostly in form of pure water, which is the essence of the freshwater transport. More interesting is the net freshwater transport in or out of a bounded region, as this relates to evaporation, precipitation and river runoff and changes of the total salinity content (zero in the steady state case) of this region. To use this concept also for a single section, the freshwater transport across a section is defined as the net mass transport, after compensating the salt transport across the section with a transport of water with a certain reference salinity. We use a, in this region characteristic value of 34.9 as reference salinity.

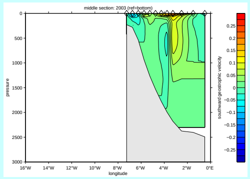
All sections seem to catch the main core of the EGC, as the total transport relative to the bottom is very similar. The freshwater transport is larger at the wider sections, most probably due to the inclusion of larger portions of the shelf. Although the velocities west of the EGC core are not large, their direction is mainly southward and the salinity is very low, leading to a larger southward freshwater transport.



Variable	Transports [2]
Mass	2.36
Salt	81.5
Freshwater[1]	900

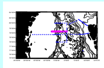
Section of the geostrophic velocity relative to the bottom at about 80°00'N (see map) and a table of the associated transports.

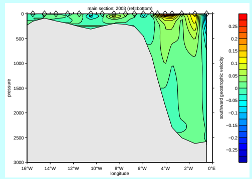




Variable	Transports [2]
Mass	2.83
Salt	97.6
Freshwater[1]	1200

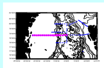
Section of the geostrophic velocity relative to the bottom at about 79°10'N (see map) and a table of the associated transports.

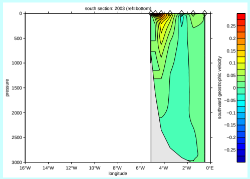




Variable	Transports [2]
Mass	2.84
Salt	97.4
Freshwater[1]	1400

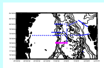
Section of the geostrophic velocity relative to the bottom at about 78°50'N (see map) and a table of the associated transports.





Variable	Transports [2]
Mass	3.15
Salt	109.3
Freshwater[1]	500

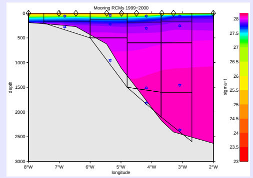
Section of the geostrophic velocity relative to the bottom at about 78°00'N (see map) and a table of the associated transports.



Mooring transports

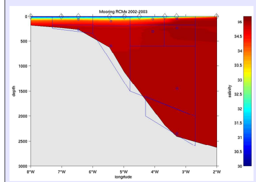
A first estimate of the transports from the mooring data was made assuming representative areas around each current measurement (see figures) and using just RCM data. The mean salinity in these boxes, used for the calculation of the salt and freshwater transports, were taken from the main section of the 2003 survey.

The volume transport is larger than in the geostrophic calculations, demonstrating that the geostrophic calculations are missing (as expected) part of the southward barotropic flow. The freshwater transport is comparable, however. This probably results from the more surface enhanced transports with low salinities in the geostrophic calculations, which are not covered by the RCM measurements. Inclusion of the near surface measurements or a better velocity mapping will most probably increase the freshwater estimates.



Variable	Transports [2]
Volume	3.4 (3.7)
Salt	120 (130)
Freshwater[1]	780 (1260)

Sections of density (upper) and salinity (lower) from the CTD survey in September 2003. Overlayed are the positions of the current meters (RCMs) and the boxes representing the areas for the transport calculations. The upper figure represents the 1999-2000 deployment period, to lower one the 2002-2003 period. The respective tables gives the associated transports.

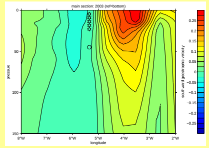


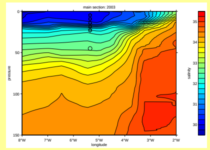
Variable	Transports [2]
Volume	3.8 (3.6)
Salt	130 (120)
Freshwater[1]	700 (800)

Near surface transport

The moorings also included some DCM current meters, which acoustically measure the velocity in 5 bins between deployment depth (usually less then 50m) and the surface. As there are still unresolved issues with some DCM data, we just show one comparison of a single box calculation with and without DCM data from the 1999-2000 deployment. The geostrophic velocity section shows that in the current core the velocity increases towards the surface. At the time of the CTD section the core was not at the mooring position, but at times during the mooring period the core region also reaches the mooring position. Due to the higher near surface velocities measured with the DCM the volume transport is higher in the calculation with the DCM data compared to the RCM only calculation. The higher near surface velocities together with the low salinity values at the surface also imply an higher freshwater transport.

Variable	Transports [2] only RCM	Transports [2] with DCM
Volume	0.14 (0.14)	0.17 (0.16)
Salt	4.6 4.7)	5.4 (5.1)
Freshwater[1]	250 (250)	350 (260)





Sections of the near surface geostrophic velocity (upper) and salinity (lower) from the September 2003 cruise along the mooring line. Hexagons shows the mean depth of the DCM current measurements, the circle shows the RCM position for the 1999-2000 period (mooring F13). The table gives the associated transports in the single box around this RCM,once with and once without the DCM measurements.

Further work

1- instead of using fixed boxes we will map the mooring velocities onto the geostrophic velocity field for the transport integration

2- include the time dependent temperature and salinity information in a similar fashion

3- better resolve the structure in the upper 100m, starting in 2003 we incorporated tube moorings in the mooring array.

4- extend the measurements onto the shelf, which was also started in 2003.

5- for a better mapping of hydrographic information with the moorings a winter section is planned, hopefully in early 2005.

1) Freshwater transports are relative to a salinity of 34.9

2) Positive transports are to the south. Volume transports are given in Sv (10^{6}m^{3}s^{-1}), mass transports in Tgs^{-1}, salt transports in Ggs^{-1} and freshwater transports in km^{3}year^{-1} . If two values are given the first is the temporal mean and the second in parenthesis is the temporal median.

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Conclusion

The calculations presented here have large uncertainties. The freshwater transport values are biased high since we are using the low near surface salinity values from summer. The mooring calculations are biased low because they are still missing the shelf region and the stronger currents near the surface. The geostrophic calculations are biased low because they miss part of the barotropic velocity component. As this is ongoing work, the transport estimates will get more reliable in near future. For the moment we can hope that the low and high biases cancel out. Our best estimate, with a large error bound, of the liquid southward freshwater transport of the EGC in Fram Strait is therefore

1000 km^{3}year^{-1}.