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FLOW OF ATLANTIC WATER NORTH OF ICELAND AND THE ASSOCIATED TRANSPORT OF HEAT

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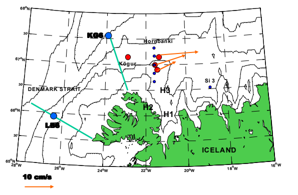
INTRODUCTION

The flow of Atlantic Water (AW) along the west coast of Iceland and onto the north Icelandic shelf is of great importance for the ecosystem there. It is rich of nutrients and creates conditions favourable for phytoplankton and zooplankton growth in the area (Thórdardottir, 1984; Ástthórsson et al., 1983). It has also been shown that this flow is important for the growth of capelin north of Iceland (Vilhjálmsson, 1997). Cod larvae are carried by this flow from the main spawning grounds southwest of Iceland to the nursery grounds on the north Icelandic shelf. The amount of AW present on the shelf north of Iceland is very variable causing variations in the living conditions.

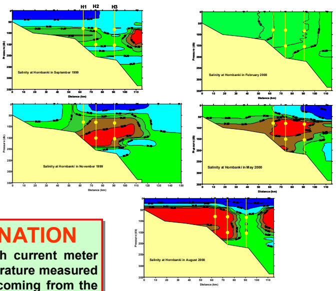
In view of these facts the Marine Research Institute has been monitoring the inflow of AW with current meters on the Hornbanki section since 1994. The region of study is shown on the map to the right. This poster illustrates some results from these measurements, and emphasizes the transport of AW and its variability and also the heat transport associated with it.



Map of the area. The red dots denote current meter positions and the blue denote CTD stations. Depth contours are 100, 200, 500 and 1000 meters.

DATA

Since 1985 the Marine Research Institute has been monitoring the inflow of AW onto the north Icelandic shelf, using Aanderaa current meters on one mooring. These measurements have been made as part of various programmes such as the Greenland Sea project, the Nordic WOCE project and the VEINS programme as well as a national project. From 1985–1994 one mooring was situated close to the Kögur section, after which it was moved to the Hornbanki section. In September 1999 the measurements were extended to three moorings (H1 (80m), H2 (80m and 150m) and H3 (80m and 150m)) with a total of 5 instruments. During the current meter measurements from September 1999 until August 2000 the section was covered 5 times with CTD.



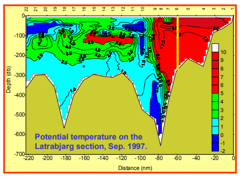
HYDROGRAPHY

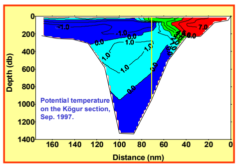
The figures to the left show the distribution of salinity on the Hornbanki section for the five times that the section was occupied from September 1999 until August 2000.

The extent of AW is quite variable in the sections. There is usually a core of AW with salinity above 35. Its position and extent is however very variable. The AW does not seem to reach deeper than 200m and below this depth colder and less saline water from the Iceland Sea is present.

Determining the outer boundary of the flow of AW is difficult with the present data set. Some evidence exists for opposite flow over the slope (Valdimarsson et al., 1999; Jónsson, 1999). When the CTD measurements have extended beyond the five stations, AW has not been found. Also measurements with ship borne ADCP (below) indicate that an appropriate point for termination of the flow of AW is at about 67°20'N which is at station 5. Inshore of H1 the ADCP measurements indicate a decrease of the current.

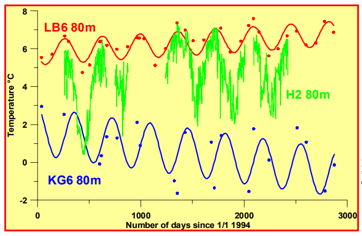
It can be argued that the fresher water seen close to the shore is really AW that has only been slightly diluted by freshwater runoff from land. This could also be the case in winter when there is a lot of mixing and no core of AW. Because of the great temporal variability in the water masses present on the section the CTD data are not very useful for determining the proportion of AW present on the section. In view of this it will be assumed that the temperature measured at the current meters is the result of mixing between water from the north and AW coming from the south. This allows the determination of the proportion of AW present at all times.

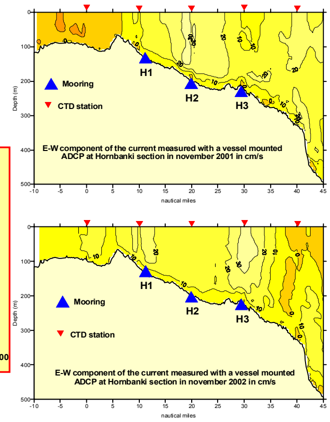


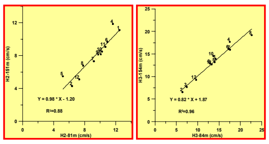


WATER MASS DETERMINATION

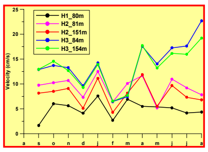
The proportion of AW present at each current meter was determined assuming that the temperature measured there forms as a mixture of the waters coming from the north with the East Greenland Current and of the AW coming from the south. For this purpose two standard stations where CTD measurements were taken 4 times each year were used. These are stations LB6 in the core of the AW and KG6 for the northern waters (see the map above). They are also shown as yellow lines on the sections to the left. For calculating the proportions, the available data were fitted with a sinusoid simulating the seasonal cycle and also a linear trend was added as it was obviously present in the data. The linear trend indicates that the contrast between the water masses is increasing during the period, i.e. the AW is getting warmer and the Polar Water becoming colder. The results of this at 80 m depth together with data from H2 at 80 m depth is shown to the right. The temperature at the current meter is almost always between the two. If it is above or below the proportions are set to 100% and 0% respectively.







Relations between the monthly mean of the E-W component of the velocity at the two depths at H2 and H3.



The monthly mean of the E-W component of the velocity at all current meters.

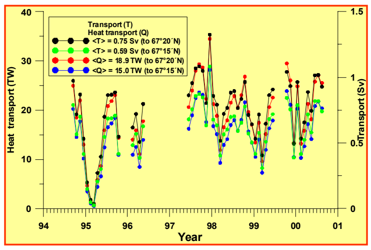
Transport associated with AW		
Outer boundary	Transport (Sv)	Heat transport (TW)
67°20´N	0.75	19
67°15´N	0.59	15

CURRENTS

The current is highly barotropic at both stations H2 and H3 as seen in the figures above. This is in agreement with the findings of (Kristmannsson, 1998) at the Kögur station, and is also found in measurements along the section with vessel mounted ADCP.

The horizontal structure of the current is more complicated than the vertical structure. The monthly mean current seems to vary seasonally at H3, being much stronger during spring and summer, while no significant seasonal variation is seen at the other moorings.

It is also seen that the current, almost without exception, increases with distance from the shore. This is especially evident during spring and summer when large values are observed at the outermost mooring.



TRANSPORT ESTIMATES

The current seems to be largely depth independent and it is therefore assumed that the current at 80m depth is representative for the current from the surface down to 115m. The current at 150m is used below that to the bottom, using a detailed bottom topography. Below 200m there does not seem to be any AW so this is used as the lower limit to the flow of AW. It is assumed that the velocity decreases linearly from the innermost mooring to 0 cm/s at 66°20´N, which is where the plots of the hydrographic sections start. South of that point there are very shallow areas towards the shore. Determining the outer boundary of the current is not obvious. For reasons discussed elsewhere in the poster the current will be assumed to terminate at station 5 at 67°20´N, but the transport to 67°15´N will also be calculated. In this way an area is assigned to each current meter and it is then multiplied by the velocity perpendicular to it and the result multiplied by the proportion of AW present at the current meter. The heat transport is calculated relative to 0°C and only the AW portion of the flow is included.

The results for the year 1999-2000 when 3 moorings were available were used to extrapolate to the years when only one mooring was present using regression analysis. The results for the monthly values of the transports are shown to the left. The average transport of AW assuming it to reach out to 67°20´N is 0.75 Sv. If 67°15´N is used as the outer boundary the transport of AW is 0.59 Sv. The corresponding heat transport associated with the flow of AW is 15 and 19 TW respectively.

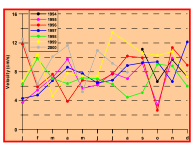
Both the transport and the heat transport is somewhat lower during the years prior to 1997 than after that period. Especially during winter 94/95 there was very little transport of AW to the north Icelandic shelf and this was reflected in the hydrographic conditions in the area during spring.

For the whole period the proportion of AW in the section was 66%, while for the period 1999-2000 it was 68%. For the period 1994-1995 it was only 36%.

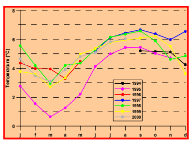
LONG TERM VARIABILITY

Current measurements have been made almost continuously at H2 since September 1994. The current at nominally 80m depth can be used to study the interannual variability of the flow of water along the shelf. The monthly means of the E-W component of the velocity is shown (right above). It shows very little seasonal and interannual variability.

A look at the temperature reveals a different story, (right below). There is a clear seasonal signal, usually with a minimum in March and a maximum in September. Interannual variability is also present in the temperature records since it is obvious that the temperature during 1995 was much lower than average for most of the year especially in winter and spring. It was also observed on CTD cruises that little AW was observed over the north Icelandic shelf. However, no significant decrease in the current was observed during this time. This may indicate that current measurements alone are not enough to distinguish what kind of water is flowing along the shelf. Since 1997 favourable conditions with strong flow of AW has prevailed off the north coast.



Monthly means of E-W component of velocity from the current meter at H2 at ca. 80m depth for different years.



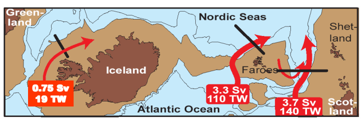
Monthly means of temperature from the current meter at H2 at ca. 80m depth for different years.

DISCUSSION

The largest uncertainty in the transport estimates is probably associated with the determination of the outer boundary of the current. Also the definition of what is AW and its variability in the section will influence the estimate.

On the figure to the right the present figures for the flow of AW and heat are superimposed on a figure from Hansen and Österhus (2000) with the inflow of AW on both sides of the Faroes. The flow of AW west of Iceland is about 10% of the total inflow to the Nordic Seas and the heat transport is about 7%.

The estimates presented here are somewhat lower than the 1.5 Sv estimated by (Kristmannsson, 1998) for the Kögur section for the period 1985-1990. During that period there was also less AW present on the north Icelandic shelf than in 1999-2000. Kristmannsson had only one mooring and might therefore easily have overestimated the current, since it is evident from the data presented here that the current is not horizontally homogeneous.



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