Seasonal Cycle of Near Surface Temperature and Salinity in Temporarily Ice Covered Regions

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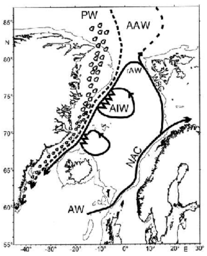
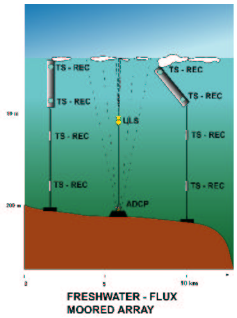
Abstract:
To get an overall understanding of the thermohaline circulation in the Arctic Ocean, the processes and transports related to the freshwater balance play an important part. A large part of the fresh water transport southwards occurs in the form of ice and liquid water within the East Greenland Current.
A new type of mooring, in which a long tube prevents damage of the instruments due to ice, was designed and deployed in two locations (about 63° N and 74°N) on the shelf in the East Greenland Current. Some minor technical problems during the first year of deployment were solved by using an improved mooring design.
From a two year long record of temperature and salinity measurements, we will show how the stratification near the surface at 74°N changes during the course of the year and how it relates to the changing ice distribution. We will compare our results from the years 2000-2001 and 2001-2002.



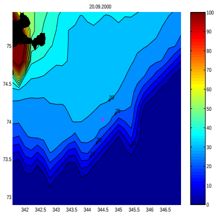
The Greenland Sea:
This map shows the water masses that mainly occur in the Greenland Sea.
Warm Atlantic Water(AW) flows from the south with the North Atlantic Current (NAC) along the coast of Scandinavia. A part of the current flows into the Barent Sea and some as part of the West Spitzbergen Current(WSC) into Fram Strait. There it recirculates and goes south as part of the East Greenland Current (EGC). This water mass is called return Atlantic Water(rAW). The other part goes into the Arctic Ocean and after some mixing returns as Arctic Atlantic Water (AAW). Cold, low saline Polar Water (including ice) flows out of the Arctic southwards into the EGC.
The major water mass of the EGC is the Polar Water which comes from the Arctic Oceans and flows south along the East Greenland shelf. Along with the Polar Water comes Arctic Atlantic Water(AAW) that is Atlantic Water which mixes in the Arctic Ocean and incorporates into the EGC. Arctic Intermediate Water (AIW) is build within the Greenland Gyre and the Islandic Gyre.



Scheme of tube mooring array. The tube protects the intruments against damage due to ice. The actual configuration has fewer instruments. ADCP data processing is still not finished.
The tube is aproximatly 40 m long, with a security line attached, in case of breaking.

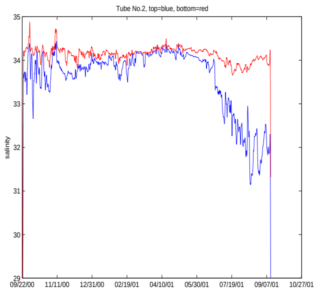
Mooring	Date	Latitude	Longitude	Water Depth(m)	Depth of TS-Sensor
Tube No.2	Sep 2000 - Sep 2001	74° 01.624 N	15° 31.230 W	358	Upper sensor: 20 m
Tube No.2					Lower sensor: 60 m
Tube No.5	Sep 2001 - Sep 2002	74° 01.678 N	15° 31.303 W	340	Upper sensor: 75 m
Tube No.5					Lower sensor: 115 m
Tube No.6	Sep 2001 - Sep 2002	74° 03.956 N	15° 45.139 W	203	Upper sensor: 21 m
Tube No.6					Lower sensor: 61 m

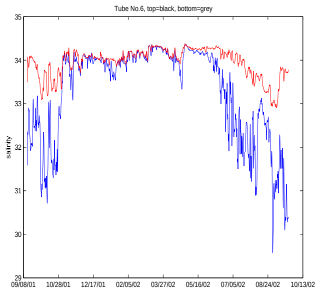
Mooring Positions

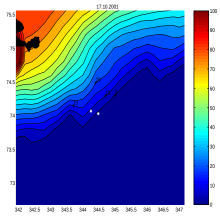


On deployment September 2000.

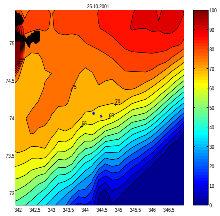
Ice concentration for first mooring period. Star indicates mooring position, tube No..2





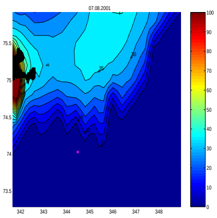


Start of Ice Formation October 2001.



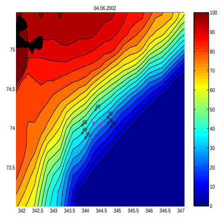
Rise in Salinity of top sensor, October 2001

Ice concentration for second mooring period. Stars indicates mooring position, tube No..5 and No.6

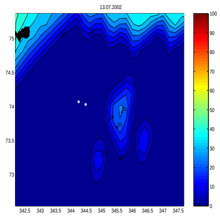


Maximum stratification August 2001

Salinity: Time series of tube mooring No. 2 and No. 6
On deployment (September 2000) the ice concentration was about 25%. The mooring stayed within the ice border during the whole summer and the top salinity did not fall below 32.6. During the winter months the salinity went down to 33.5. By the end of June 2001 the salinity starts to fall and has its lowest value on 14th of August. Beginning November 2001 the top salinity begins to rise and reaches its average winter level of 34.2 on the 6th of November. The bottom salinity starts to rise a little bit later. By the 16th of June the salinity at the surface starts to decrease, about three weeks earlier as in 2001. A warm, fresh surface layer builds up.
The salinities recorded by the lower sensor are always higher than of the top sensor. Changes in salinity are mostly first recognized by the top sensor as expected for a forcing from ice/atmosphere.
During the first year of recording data, there was much more ice than during the second. It is natural that the ice takes longer to melt away. In summer 2001 the ice is gone by the 8th of Semptember.

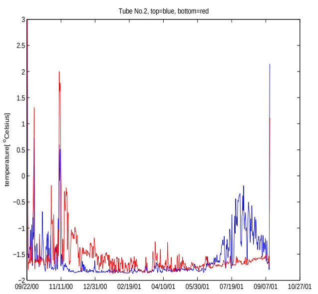


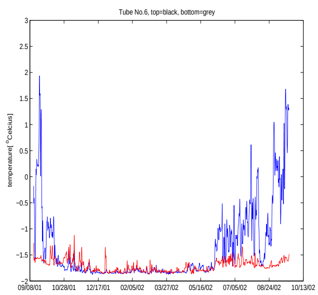
Begin of Ice Melting June 2002



Surface freshening ends , July 2002

Temperature: Time series of tube mooring No. 2 and No. 6
In 2000 the highest temperature measured by the top sensor is 0.73°C on the 1st of October. Around the 8th of November there is an occasion with relative high temperatures, especially a rise in the bottom sensor to temperatures of nearly 2°C. The rise is also found in the salinity data, which is probably an inflow of rAW. Return Atlantic Water has higher temperatures and salinities than the ambient PW. After this event the temperature measured by the top sensor stays at about freezing point. Temperature starts to rise again by the 11th of June 2001. The highest temperatures are -0.2°C by the 5th of August. In comparison with ice charts, the ice cover is receding from mid June on. The mooring is for the first time outside the ice border by the 7th of August.





At the beginning of September 2001 the top temperature rises up to nearly 2°C and it drops, after some peaks, to freezing point around the 28th of September 2001. Ice charts show the beginning of ice formation, by 17th of October. By the 4th of June, the temperatures of the top and bottom sensors start to rise constantly. At the beginning of July 2002 a warm,fresh surface layer has establised.
During the winter months temperatures measured by the bottom sensor are higher than those of the top sensor. When the summer stratification has estabilshed top temperatures are higher. The highest top temperatures in summer 2001 and 2000 were found at the end of September with almost the same values. Due to longer, heavier ice cover, the temperature during the first deployment is lower than during the second.

Conclusions:

The stratification of the salinity is low in winter. In summer the ice melts, lowering the salinity in the upper layer and therefore increasing the stratification. A similar seasonal cycle is found in the temperature.
In winter when the temperature drops convection starts and the water gets mixed, until it reaches the freezing point and ice formation starts. If the surface is covered with ice there is no thermal convection possible and the temperature stays just above the freezing point.
Interannual variability in stratification can be attributed to different ice conditions.

Outlook:

In addition to the data of the tubes, we will use CTD data and current meter measurements to calculate the frehswater transport within the EGC. This will also be done with the moorings deployed at 63°N.

Data of ice concentration: http://www.nsidc.org/data/nsidc-0002.html

Reference: data of ice concentration: NASA Team Data, Cavalieri, D., P. Gloerson, and J. Zwally. 1990, updated 2002. DMSP SSM/I daily polar gridded sea ice concentrations. Edited by J. Maslanik and J. Stroeve. Boulder, CO: National Snow and Ice Data Center. Digital media.

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