4. HYDROGRAPHIC CONDITIONS IN THE GREENLAND SEA

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Objectives

Bottom water renewal in the Greenland Sea by deep convection in interplay with ice coverage and atmospheric forcing is a major element of the water mass modification in the Arctic Mediterranean. Effects influence both the central Arctic Ocean and the overflow waters into the Atlantic. Since the hydrographic observations became more frequent in the late 1980s, no bottom water renewal by winter convection took place, however. Under these conditions, the deep water properties change towards higher temperatures and salinities. Furthermore, the doming structure in the Greenland Gyre, as it was observed in the mid-80s, was superseded by an essentially 2-layered water mass distribution with a marked density step which is located presently at about 1500 m. The specific objectives of the project, which is incorporated in the EU funded CONVECTION, are

- to investigate the relative importance of atmospheric forcing parameters for winter convection,
- to clarify whether ice coverage inhibits or facilitates deep convection,
- to build a long term observational basis about deep water changes in the Greenland Gyre, and
- to contribute to the decision which deep water exchange mechanisms are at work under the absence of deep winter convection.

Work at sea

In the central Greenland Sea, a long term zonal CTD transect at 75°N has been performed with a regular station spacing of 10 nautical miles (Fig. 2 and 7). This distance has not been reduced at frontal zones in order to gain time for a couple of stations dedicated to the investigation of an convective eddy which had been detected earlier and had been marked with an APEX float to facilitate its identification.

Two in house developed EP/CC (externally powered/compressibility compensated) Jojo moorings have been exchanged during splendid weather conditions. One additional Jojo mooring has been deployed according to the EU contract of the project CONVECTION. Deployments and recoveries revealed no problems and all equipment worked faultlessly.

This is also true for the CTD work. It is not possible to describe the full details of calibration and data procedures here. A few hints may suffice to give an idea about the general procedure. We use the same sensors already for a number of years and checked for their performance with respect to unwanted cross dependencies. According to this, one of the temperature sensors shows a pressure sensitivity of roughly 1.5 mK/4000 dbar while no pressure or temperature dependence of the conductivity sensors could be found. To identify the latter is close to impossible in the field (within the polar oceans) because of the high gradients in the upper water column where temperature differences occur. The locations of in-situ comparisons have been chosen carefully by checking for each data point whether a comparison is allowed or inadmissible. As there is no suitable location in Fram Strait except the deep waters of Molloy Deep, the opportunity for an in-situ comparison there has been used. Duplicate sensors have been utilized throughout, with varying positions on the CTD. Time alignment has been optimised for each flow path separately (stations 54 and 75) and will be applied together with final post cruise calibration. The difference between pre-cruise and post-cruise calibration is normally in the range of a few mK and a few 1/1000 in salinity. Bottle sample salinities of triple samples are determined as a rough check on board, in the lab on land, and by Ocean Scientific.

In addition to the standard parameters, the following properties have also been measured: Chlorophyll fluorescence (Haardt), oxygen (SBE43, first test), and transmission (Seatech, 30 cm).

Preliminary results

The most outstanding single feature of the survey in the Greenland Sea was certainly the convective eddy, which was revisited for the second time after its detection in early spring. This feature represents the deepest convection level observed in recent years. It was found close to the Greenwich Meridian a few miles south of 75°N. The homogeneous water column extended to about 2300 dbar, with the ubiquitous temperature maximum (found usually at medium depth levels of some 1500 to 1700 m) displaced downwards to 2700 m. The feature has been covered with five stations which showed that at present the APEX drifter is not located exactly in the centre of the eddy. The eddy contains water which is denser than the surrounding at low pressure levels (about 600 m), but considerably less dense at higher pressures. This indicates that the water within the eddy is not likely to replace bottom water. There are indications that the eddy may not have been formed during the last winter but before and that its lifetime exceeds one year.

A second eddy with a similar structure was observed during on the regular transect at about 2°W. The temperature maximum was located at a slightly smaller depth level (2200 dbar). No attempt has been made to investigate its horizontal extent or identify its centre. The nearby Jojo mooring at 2°30' W captured the passing of such a structure which belongs presumably to the same eddy. The mooring data show that the vertical extent of the homogenized water column exceeds greatly the actual winter ventilation depth in mid winter.

The conditions within the two eddies differ from those in the surrounding waters where winter convection did not penetrate through the temperature maximum and is confined mostly to about 1000 m. Since the water properties in 2000 and 2001 are very similar, the Jojo moorings serve as the best indicators for winter ventilation depth. A generally valid estimate the depth level of the temperature maximum is not possible because of the distortions of the isotherms induced by the eddies. In the mid gyre a depth level of roughly 1700 dbar is observed. However it is beyond any doubt, that the warming of the bottom waters, observed during the last years, continued with at usual rate of about 10 mK/year. The temperatures in the bottom waters increased e.g. from -1.145°C (potential temperature) in 2000 to -1.131°C in 2001 at 1°W. Consequently, the isotherm of e.g. -1.10°C is found at a greater depth in 2001 than in 2000 (3250 m and 3100 m respectively) in the central basin.

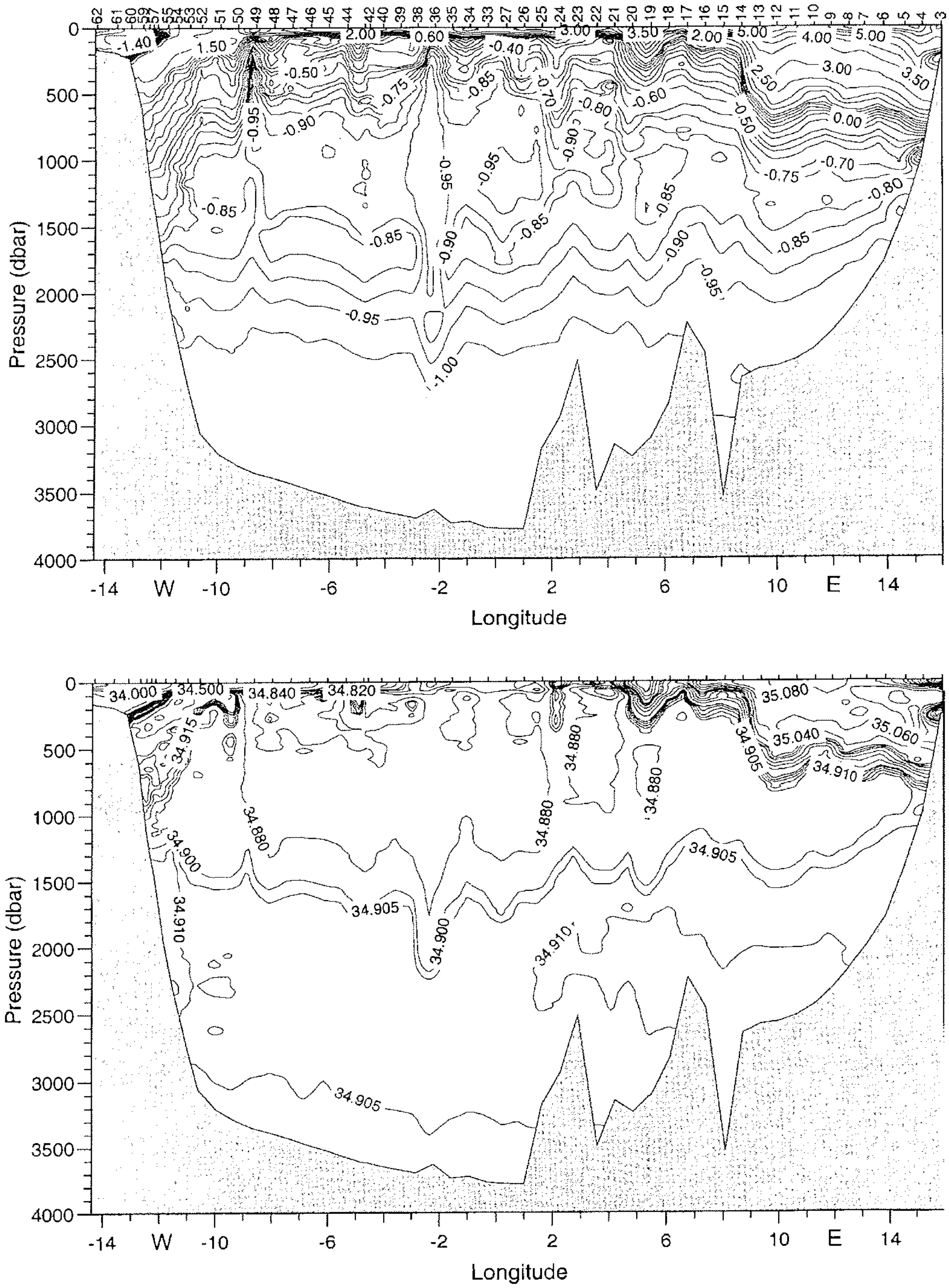

Fig. 7: Transect of potential temperature and salinity across the Greenland Sea along 75°00'N. For location see Fig. 2.

Abb. 7: Vertikalschnitt der potentiellen Temperatur und des Salzgehalts durch die Grönlandsee auf 75°00'N. Zur Lage des Schnitts, siehe Abb. 2.