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Ocean Temperatures at Fylla Bank, West Greenland
Related to Atmospheric Processes

by

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The temperature and salinity conditions in the waters off West Greenland show great interannual variability not only in the surface layer but also in deeper layers, Buch (1984). Within the last quarter of the century two climatic extremes have been observed. Both of them can be explained by anomalies in the atmospheric conditions in the North Atlantic region (Buch and Stein, 1987). During the first period of negative temperature and salinity anomalies the anomaly pattern was advected to West Greenland waters by the East Greenland Polar Current, while during the second period the anomaly was a result of direct air - sea exchange processes in the Davis Strait.

Besides these two extremes it is also of interest to investigate in further detail which processes are of importance to the more "normal" interannual variability. The processes can according to Buch (1987) be divided up into two main parts:

a) Local air - sea interaction

b) Horizontal and vertical transports

Data available do not permit a detailed analysis of each of these processes, for which reason we here restrict ourselves to some comments on their importance based on a simple correlation analysis.

1. Local air - sea interaction

The present study of the general linkage between air - and ocean temperatures in the West Greenland area will be based on the time series of hydrographical observations from the Fylla Bank Stations 1 to 5, see Fig. 1, together with air temperatures observed at the Nuuk/Godthaab Meteorological Station.

The time series of temperature and salinity observations from the Fylla Bank section dates back to 1950 for the months of June and July, and to 1963 for November. Observations of meteorological data have been performed at the Nuuk/Godthaab station continuously since 1876.

The Nuuk/Godthaab Meteorological Station is the observation site of air temperature nearest to the Fylla Bank stations. However it cannot be excluded that the location of the station 10 n.m. inside the Godthaab Fjord system implies that air temperatures recorded differ from those in the Fylla Bank area.

Stein and Buch (1989) performed a correlation analysis on mid-June mean temperatures observed at the Fylla Bank St. 2 (top of Fylla Bank, depth: 44m) versus each of the monthly mean air temperature series for the 25 year period 1963-1987. The result is shown in Fig. 2. It appears that correlation between air temperatures and the mid-June ocean temperature shows an annual spectrum which peaks in May and August/September. Correlation coefficients above 0.5 are found in the period April-September, the maximum values being 0.63 in May, 0.67 in August and 0.63 in September, respectively.

This correlation spectrum indicates that the air temperatures in May influence the mid-June ocean temperatures, whereas the August-September air temperatures are determined by the June ocean temperatures.

A similar correlation analysis has been performed on the air temperatures versus the ocean temperatures of the upper layers (0-50m) at the five Fylla Bank stations in July for the period 1950-1989 (Fig. 3).

It is noticed that with regard to the linkage between the July ocean and air temperatures the three innermost stations show good correlation, with a maximum of 0.70 at Station 1, while the two outer stations west of the bank do not correlate well with the July air temperature in Nuuk/Godthaab. The reason for this difference may be twofold:

- the increased distance to the meteorological observation point.

- the two stations west of the banks are influenced by water advected to the area.

Bearing in mind that during this part of the year the inflow of East Greenland Polar Water is at its maximum, and that the core of this water mass is situated just west of the bank, the last explanation seems very likely.

It also appears from Figure 3 that the July ocean temperatures, like the June ocean temperatures, correlate well with the August air temperatures. Compared to the July correlations, the August correlations have decreased for Station 1 and 2, Station 3 is at the same level, while the correlations has increased for the two outer stations. However all stations show fairly good correlations.

Thus the ocean temperatures in June and July, respectively, are well correlated to the August air temperatures, indicating an ocean influence on the atmospheric conditions in the Nuuk/Godthaab area. The decrease in correlation from July to August for Station 1 and 2 and the increase for Station 4 and 5 cannot easily be explained.

In addition to the analysis of the mid-June ocean temperatures, Stein and Buch (1989) also investigated the correlation between the air temperatures and the mean ocean temperatures of the upper 200 metres observed at Fylla Bank St. 4 in

November. The result is shown in Fig. 4. The relationship between the atmospheric temperatures in August/September and the ocean temperatures in the Fylla Bank area in November is prominent. The correlation coefficients are 0.57 for August and 0.64 for September, respectively.

If the analysis is performed for all five Fylla Bank stations, considering only the surface layer (0-50m) (Fig. 5) it is seen that the November ocean temperatures still are best correlated to the September air temperature. It is also noticed that, like in July, the highest correlation coefficients are obtained for the stations closest to shore.

It is remarkable that compared to the analysis performed by Stein and Buch (1989), who used the mean temperature of the upper 200 metres at Fylla Bank St. 4 and found a correlation coefficient of 0.64 to the September air temperature, the present analysis, using only the upper 50 metres, gives a correlation coefficient of only 0.48 for Station 4.

The fact that the November ocean temperatures are best correlated to the August/September air temperatures may be explained by the fact that during these months the atmospheric heating attains its maximum. Heat is transferred to greater depths by vertical mixing. Because of the higher heat capacity in water compared to air, portions of this heat are still "stored" in the water column in November, especially at some depths, because a thin surface layer is expected to be cooled by the cold November atmosphere. This explains the above mentioned decrease in correlation coefficient, when the air temperature is compared to the upper 50 m instead of to the upper 200 m at Fylla Bank St. 4.

In this connection it should be remembered that the August air temperatures are well correlated to the June and July ocean temperatures. The following line of relationships is suggested:

Air temperatures (May - July)
advection.

↓

Ocean temperatures
June - July.

↓

Air temperatures
August.

↓

Ocean temperatures
November.

It is therefore expected that the ocean temperatures in November are related to the ocean temperatures during the summer. Stein and Buch (1989) investigated this and found a correlation coefficient of 0.54 between the November and the June ocean temperatures at Fylla Bank St. 2.

The above given analysis shows, that the exchange of heat between ocean and atmosphere is a decisive factor to temperature conditions in the West Greenland surface waters as could be expected. It is known from the heat equation, that advective processes are also a very important factor in determining the hydrographical conditions of a certain area. It was demonstrated above, that in July the correlation between the air temperatures and ocean surface temperatures at the Fylla Bank stations decrease from the innermost towards the outermost station, indicating that other processes may influence the hydrographical conditions in offshore region i.e. west of the bank. The inflow of East Greenland water attains its maximum in June/July in the Fylla Bank area. This subject is discussed below.

2. Advective processes

Sloth and Buch (1988) found a close relationship between the ice cover in the Greenland Sea in December and the temperatures at Fylla Bank the following June and July, thus documenting the prominent influence of the East Greenland Current on the West Greenland waters. This influence was traced to a depth of 400 m, while temperatures in the 400-600 m depth interval showed only weak correlations to the ice concentrations in the Greenland Sea, probably because this layer is dominated by inflow of Atlantic water.

The flow of the North Atlantic Current is coupled to the intensity of the Westerlies, which again depends on the air pressure difference (NAO-index) between the subtropical High near the Azores and the subpolar Low near Iceland. For this reason an analysis of a possible relationship between the NAO index representing the winter months December-February and the hydrographical conditions in the 400-600 m layer of Fylla Bank has been carried out. The results are given in Table 1.

This analysis shows that there exists a negative correlation between the NAFO winter index and the Fylla Bank 400-600 m temperatures, the correlation increasing from July to November.

With regard to salinity there exists only a negative correlation of any importance between the NAFO-index and Fylla Bank St. 5 salinity in July.

The highest correlation with regard to temperature is found at St. 5, (the westernmost station) especially in July. The decrease in the difference between St. 4 and St. 5 from July to November is most likely due to the fact, that the intensity of the inflow of Atlantic Water to the West Greenland area is highest late in the year, whereby the station closest to shore is more influenced by the inflowing Atlantic water due to the action of the Coriolis Force.

The Atlantic water entering the West Greenland area originates from the northern limit of the North Atlantic Current in the area south-southwest of Cape Farewell, Buch (1990). An increase in the NAO-index means an intensification of the westerlies, which again affects the intensity of the North Atlantic Current, and according to the heat equation higher wind velocities affect the heat exchange between ocean and atmosphere. The negative correlation between the winter NAO-index and the subsurface temperatures off West Greenland, together with the missing correlation with the salinities (except for Station 5 in July) from the same depth interval, mean that an increase in the intensity of the westerlies in the North Atlantic results mainly in a decrease in the temperatures of the Atlantic water component of West Greenland, most noticeable in the following November.

With regard to salinity, an effect is only traced at the westernmost station at the Fylla Bank section. Myers et. al (1988) reported a correlation between NAFO index and the salinities off Fylla Bank, but unfortunately they used salinity data only from St. 5 in their analysis.

These findings suggest that it is mainly the increased heat transport from ocean to atmosphere, as deduced from the heat equation, which is the result of a change in the intensity of the westerlies in the area in which the Atlantic water entering the West Greenland area originates.

It must, however, be stressed that the data on which these conclusions are drawn are very limited, and further research into this field is required, combined with observations from other ocean areas in the western North Atlantic, especially in the areas south of Cape Farewell.

3. Conclusions

It can be concluded that the hydrographical conditions along the West Greenland fishing banks are governed by processes in the large-scale atmospheric circulation as well as by local processes.

The large-scale atmospheric circulation and especially its variability have a direct effect on the current systems transporting water to the West Greenland area. Local air-sea interaction has a direct effect on the temperatures of the ocean surface layer, but the local processes are most likely related to the large scale circulation system too.

It is, therefore, essential for a better understanding of the physical oceanography of ocean areas off West Greenland to have a detailed knowledge of the large scale atmospheric circulation system and the processes that drive its variation together with air-sea exchange processes.

REFERENCES

Buch, E., (1984). Variations in temperature and salinity off West Greenland since 1970. NAFO Scientific Council Studies No. 7, pp. 39-45.

Buch, E., (1987). Preliminary Considerations on the Heat Transport in West Greenland Waters. NAFO SCR Doc.

Buch, E., (1990). A Monograph on the Physical Oceanography of the Greenland Waters. In press.

Buch, E., and M. Stein, (1987). Time series of temperature and salinity at the Fylla Bank section, West Greenland. C:4 Hydrographic Comm. ICES Annual Meeting 1987.

Myers, R. A., S. A. Akenhead and K. Drinkwater, (1988). The North Atlantic Oscillation and the Ocean Climate of the Newfoundland shelf. ICES C.M. 1988/C:12.

Sloth, P. and E. Buch, (1988). Correlation between Winter ice coverage in the Greenland Sea and the summer temperatures at Fylla Bank, West Greenland. NAFO SCR Doc. 88/49, 7 p.

Stein, M. and E. Buch, (1989). Are subsurface ocean temperatures predictable at Fylla Bank/West Greenland. NAFO SCR Doc.

Table 1. Correlation coefficients between the winter NAO-indices and 400-600 metre depth level temperature and salinity from Fylla Bank St.4 and 5 the following July and November.

July				November			
St.4		St.5		St.4		St.5	
T	S	T	S	T	S	T	S
-0.46	-0.27	-0.56	-0.55	-0.61	-0.25	-0.64	-0.07

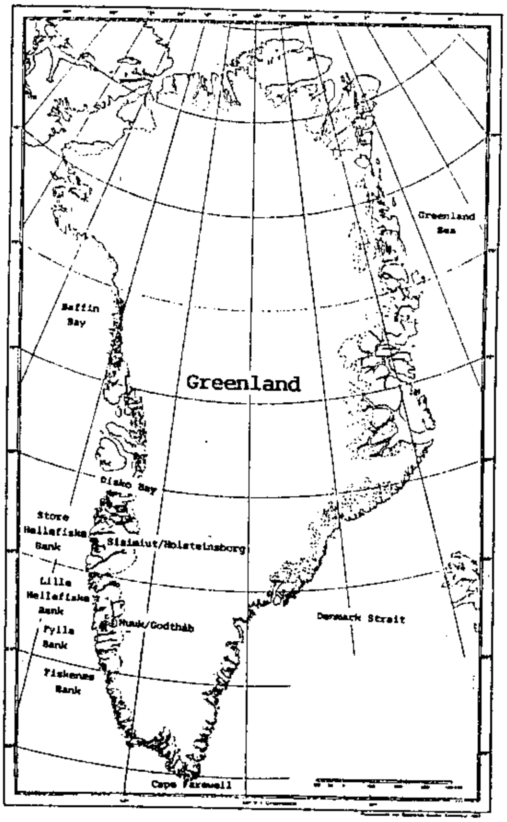

Fig. 1. Map of the area.

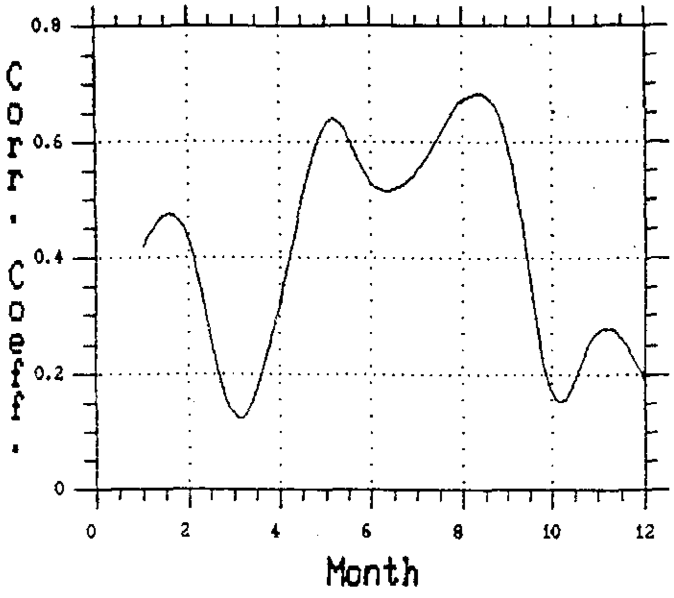

Fig. 2. Correlation spectrum Fylla Bank St. 2 mid-June temperature versus Nuuk monthly mean air temperatures. After Stein and Buch (1989).

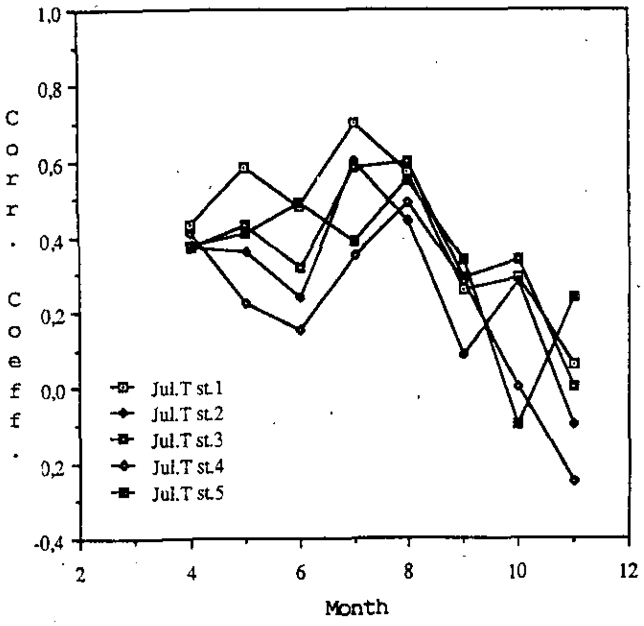

Fig. 3. Correlation spectrum for the July surface layer temperature at the five Fylla Bank stations versus Nuuk monthly mean air temperatures.

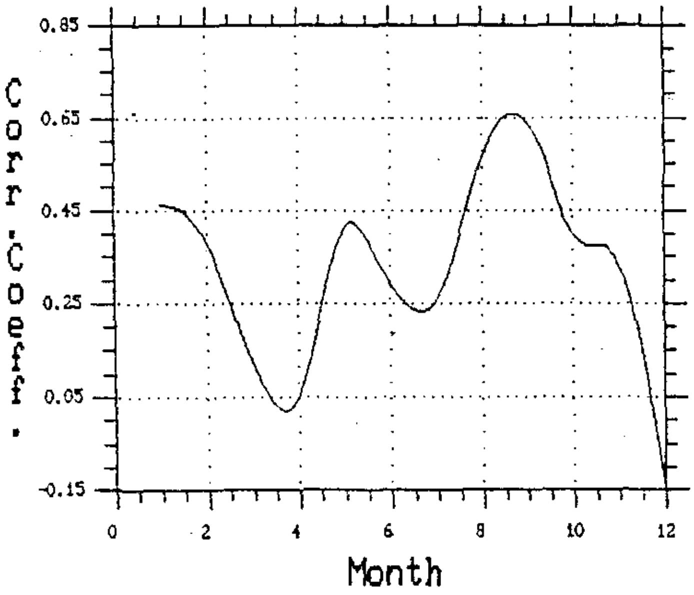

Fig. 4. Correlation spectrum Fylla Bank (St. 4) 0-200 m temperature anomaly versus Nuuk monthly mean air temperatures. After Stein and Buch (1989).

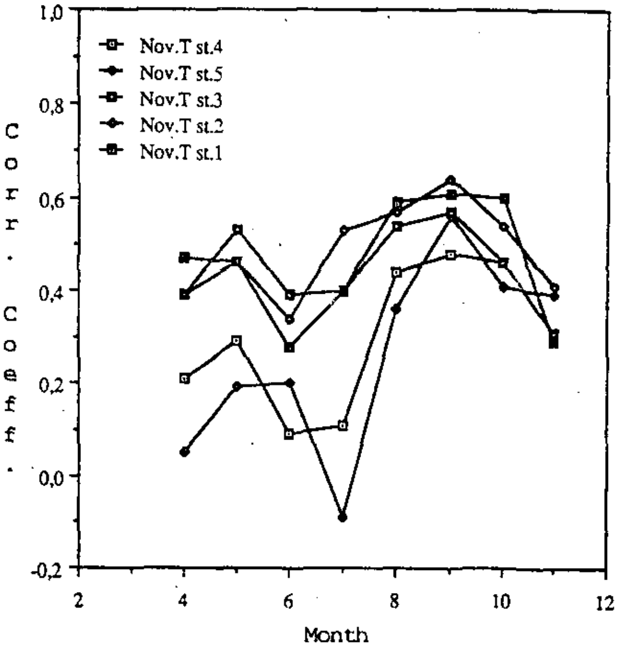

Fig. 5. Correlation spectrum for the November surface layer temperature at the five Fylla Bank stations versus Nuuk monthly mean air temperatures.