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Correlation Between Winter Ice Coverage in the Greenland Sea and the Summer Temperatures at Fylla Bank, West Greenland?

by

Peter Sloth

Geophysical Institute, University of Copenhagen
Haraldsgade 6, DK-2200 Copenhagen N. Denmark

and

E. Buch

Greenland Fisheries Research Institute
Tagensvej 135, DK-2200, Copenhagen N. Denmark

1. Introduction.

For almost four decades the Greenland Fisheries Research Institute has carried out hydrographical investigations at the most important fishing banks off West Greenland, whereby valuable timeseries of temperature and salinity have been established, reflecting some of the climatic variations in the area. In particular have the timeseries of temperatures on top of Fylla bank in the middle of June (Fig. 1) been used in climatic interpretations.

Also in the fisheries biology have the mid - June temperatures on top of Fylla Bank been used, since there seems to be a connection between this temperature and the yearclass strength of cod at West Greenland (Hansen and Buch, 1986) except for years when there is believed to be an inflow of codlarvae from the Icelandic spawning grounds.

Taking the heat equation as a starting point Buch (1987) analysed which physical processes are of importance to the sea-temperature conditions off West Greenland. The analysis concluded that the temperature of the surface layer as well as its interannual variations, are very much dependent on the heat exchange between ocean and atmosphere and in particular on the inflow of water from other parts of the North Atlantic current systems. Thereby the temperature conditions off West Greenland are ruled to a great extent by atmospheric and oceanic processes, including the balance of the heat equation, in other and distant parts of the North Atlantic.

During spring the hydrographical conditions around the West Greenland fishing banks south of about 65 - 66°N are very much dominated by the inflow of cold water from the East Greenland Current which originates in the Polar Basin. Actually the inflow attains its maximum intensity in June in the Fylla Bank area. It is therefore reasonable to believe that the mid - June temperatures on top of Fylla Bank can be related to the climatic conditions, vizualised by the distribution and concentration of sea ice, over the Greenland- and Iceland Sea area the previous winter.

The subject of the present paper is therefore to present some preliminary results of an investigation of a possible correlation between the sea ice distribution and concentration in the Greenland- and Iceland Seas and the summer temperature conditions on top of Fylla Bank the following year.

2. Sea Ice in the Greenland Sea.

The sea ice concentrations at East Greenland in the Greenland Sea and in the Iceland Sea show large seasonal and interannual variations. Briefly the ice cover during winter consists of two types of sea ice. The oldest and thickest is advected from the Arctic Ocean by the East Greenland Current passing down south over the continental shelf along the eastcoast of Greenland. Additionally new ice forms in the Greenland Sea every winter.

The new first year ice will have a maximum mean thickness of 1 - 2 metres, while the older ice will have a mean thickness of some metres, typically 3 - 4 metre. The keel depth can occasionally be of the order of tenths of metres in connection with ridging.

It has been confirmed by submarine based observations (Wadhams, 1983), that the ice advected from the Arctic Ocean consists of ice from various parts of the Arctic Ocean.

The ice flux through the area depends on the ice thickness and on the drift velocity. Observations have shown that the drift velocity increases with the distance from the shore-fastened ice and that the mean ice drift increases with the distance from the ice edge, Wadhams (1983). Consequently the ice flux will attain its maximum somewhere in between the fast ice and the ice edge.

The dynamics of the East Greenland Current are of major importance to the ice conditions. The current is confined mainly to the shelf. The permanent Polar Front, separating the Polar water from the Atlantic surface water, is to some degree also the limit of the ice cover, although meteorological forcing at times makes the presence of ice possible east of the Polar Front followed by melting of large amounts of sea ice in the warm Atlantic surface water.

The Polar Front is not a smooth line, but rather dominated by a wave - like structure consisting of eddies with a size of the order 60 - 100 kilometers. Variations in the front caused by melting ice near the edge form somewhat smaller sized eddies of the order of 20 - 40 kilometers.

Despite of all these factors influencing the ice cover in the

Greenland- and Iceland Sea authors believe, that the year to year variations in the concentrations of the ice cover during wintertime to some degree reflects the amount of cold and relatively fresh Polar water present in the East Greenland Current.

The Polar water flows along the coast of East Greenland, rounds Cape Farewell and continues along the westcoast of Greenland until a latitude of around 65 - 66°N, where it turns westward. This means that high ice concentrations in the Greenland Sea as a result of a great outflow from the Arctic Ocean could result in low temperature conditions at the West Greenland fishing banks some months later, indicating the possibility that the sea-ice concentrations within the Greenland Sea during wintertime could be used to predict the temperatures at the Westgreenland fishing banks the following summer.

3. Analysing method and results.

In order to investigate this theory in further detail digital ice maps from 1953 - 77, elaborated by John E. Walsh, University of Illonois, were used to calculate mean ice concentrations of the Greenland - and Iceland Seas, see Figs. 2a and 2b. (these ice data can be obtained on magnetic tape from World Data Center A, University of Colorado, Boulder, Colorado U.S.A.).

By correlating the sea-ice concentrations in the area indicated in Fig.2a with temperature observations from the Fylla Bank st.2 (station placed on top of the bank. depth 44 m.) from the months of June, a rather convincing correlation was found between the ice concentrations in the Greenland Sea in December and the temperature at Fylla Bank in June the following year (Fig. 3) indicating a transport time from the Greenland and Iceland Seas of approximately 6 months.

Correlating the ice cover in the month of May with the Fylla Bank temperatures in November did not show the same high correlation. This was not to be expected since Buch (1984) has shown, that the inflow of Polar water to the West Greenland fishing banks has its maximum influence in June - July, then decreasing to almost zero during autumn and winter.

Using a slightly different area, Fig. 2b, for estimation of the ice cover shows the same high correlation between the December ice cover and the Fylla Bank June and July temperature, the correlation coefficient being 0.71, Fig. 4.

Following the same procedure for watermasses of different depths at Fylla Bank st. 4 (just west of the bank) the same results appear for the watermasses from the depthintervals 0 - 50 metres, 50 - 150 metres and 150 - 400 metres, Fig.5. As could be expected only a weak correlation is found for the 400 - 600 metre depthinterval, since this interval is dominated by inflow of water from the Irminger Sea and is influenced by Polar water only through vertical mixing, which is normally weak.

The results obtained may be used as a forecasting model for the temperature conditions at Fylla Bank in June and July. As data on the ice concentrations in the Greenland- and Iceland Seas in November, December 1987 and January 1988 not are avai-able in the same format as have been used for the *present* analysis, a direct prognosis cannot be made, but observations of the ice concentrations performed by various agencies have shown that the concentrations of ice in the Greenland- and Iceland Seas have been greater than the previous two winters (Valeur, pers. comm.). Additionally observations of cold polar water north of Iceland in the months of February and May have been made on icelandic research vessels for the first time since 1984 (Malmberg, pers. comm.). These informations indi-cates that the outflow from the Polar Ocean have been increas-ing relative to the previous winters, although it seems as if some of higher ice concentrations are due to very low air temperatures over the Greenland Sea area (7°C below normal) i.e. a greater than normal formation of new ice. Pooling these informations makes us give a very guarded estimate on the mid - June temperature on top of Fylla Bank in 1988 to be between 1.5 - 1.7°C.

4. Discussion.

As mentioned in the introduction the purpose of this paper is to give the preliminary results of an attempt to correlate the concentration of sea-ice in the Greenland- and Iceland Sea during wintertime with the temperatures observed at Fylla Bank the following summer. The results have been promissing although of course with some scatter in the results, but it must be remembered that the findings of Buch (1987) showed that the temperatures in the West Greenland area are influenced by advection as well as by exchange processes with the atmosphere. This means that also the temperatures at Fylla Bank are influ-enced by local as well as large scale meteorological events, Buch *and* Nielsen (1988). The next step to attain further under-standing of the processes influencing the temperature condi-tions in the West Greenland area will therefore be to develop a model taking into account the influence of both advection and air - sea interaction.

Another source of error shall be seeked in the estimation of ice concentrations, since this estimate takes into account new ice as well as ice advected from the Polar Ocean, the latter being the importent one in this context. The proportion be-tween these two types of ice will differ from year to year which will disturb the results of the correlation analysis.

5. Acknowledgements.

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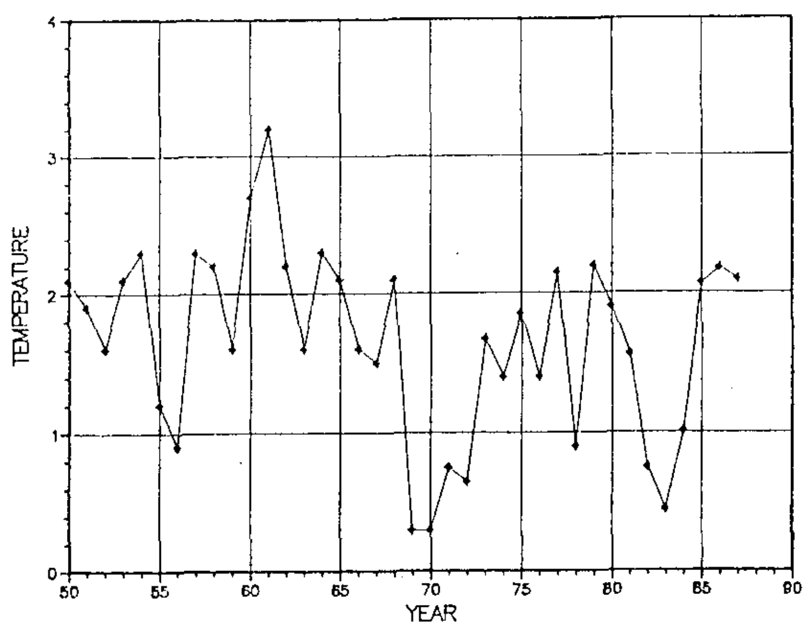

Fig. 1.
Mean Temperatures on top of Fylla Bank, mid-June for the period 1950-87.

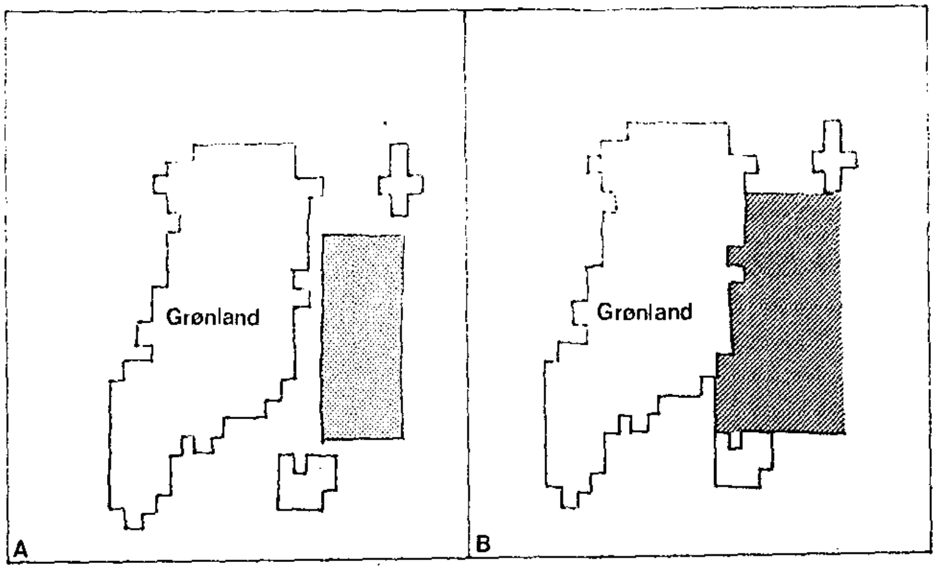

Fig. 2a, b

Areas used for calculation of ice concentration, based on digital icemaps prepared by John E. Walsh, University of Illonois.

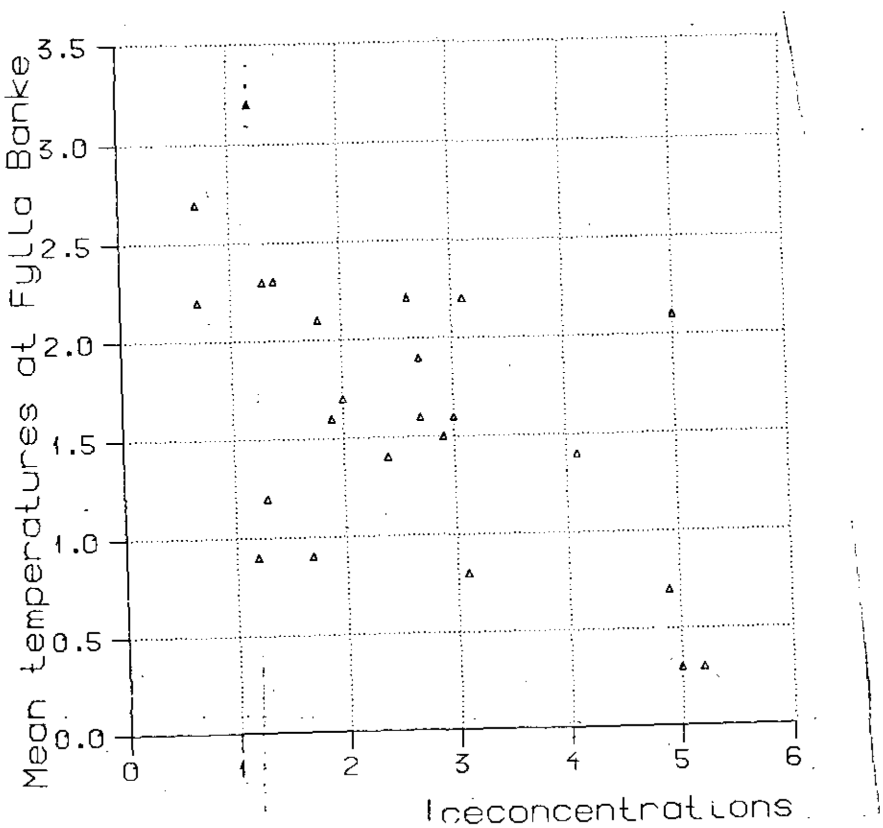

Fig. 3.

Ice concentrations in the Greenland- and Iceland Sea area in December plotted against temperatures at Fylla Bank, Station 2 the following June.
The area indicated in Fig. 2a has been used, and the ice concentration is measured in tenths of this area.

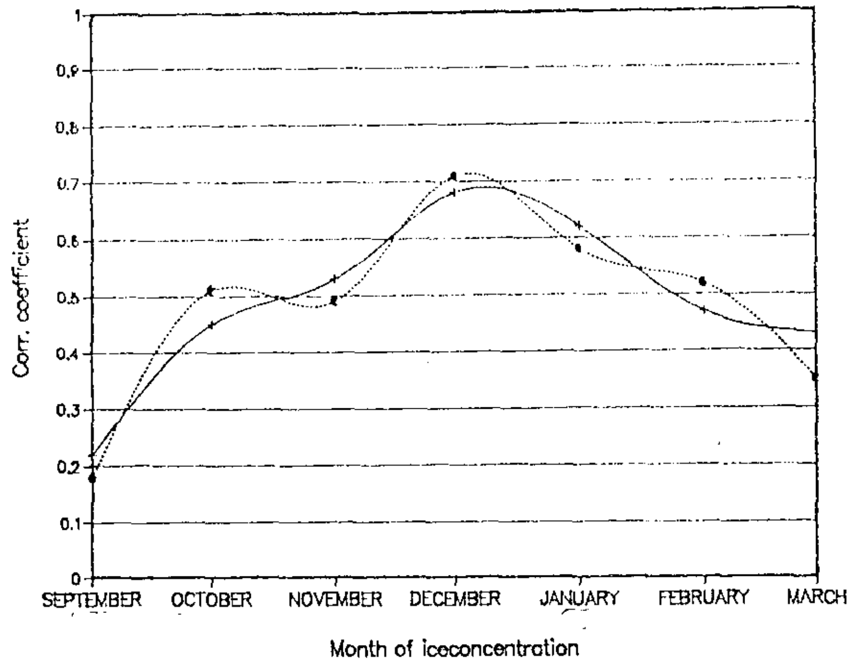

Fig. 4.

Correlation coefficient between the ice concentrations in the Greenland- and Iceland Sea for each of the months September to March and the temperatures at Fylla Bank st. 2 the following June and July.
The calculations are based on time series from 1953-77.
The area indicated in Fig. 2b has been used.

—+— June temperatures
---●--- July temperatures

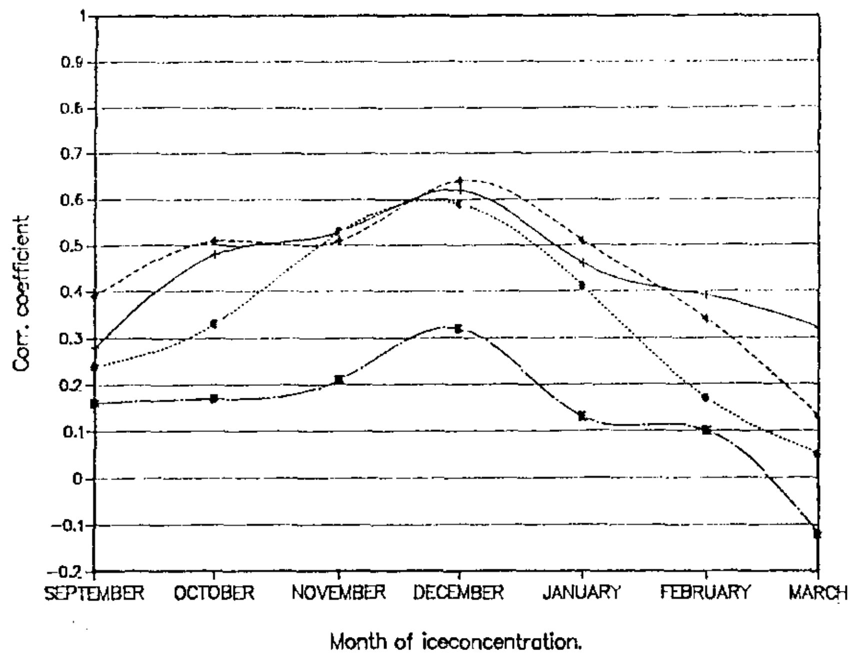

Fig. 5.

Correlation coefficients between the ice concentration in the Greenland- and Iceland Sea for each of the months September to March and the temperatures at Fylla Bank st. 4 the following July for 4 different depth intervals.
The calculations are based on time series from 1953-77.
The area indicated in Fig. 2b has been used.

—+— 0- 50 m.
----◆---- 50 - 150 m.
······●······ 150 - 400 m.
-----■----- 400 - 600 m.