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Are Subsurface Ocean Temperatures Predictable at Fylla Bank/West Greenland?

by

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ABSTRACT

The paper tests the hypothesis whether subsurface ocean temperatures off the shelf-break and on top of Fylla Bank are predictable from air temperature data sampled at Godthaab/West Greenland. It would appear that late summer air temperature conditions steer the upper ocean layer temperatures (0-200m) as observed in November. A general warming trend apparent in the meteorological time series is not found in the ocean time series due to the shortness of the time-window of the latter series.

INTRODUCTION

The hydrographic scenario off West Greenland is governed by the West Greenland Current system which is composed of two main components, the cold East Greenland Current component, and the warm Irminger Current component (BUCH, 1982; STEIN and BUCH, 1985a). Accordingly, the cold, near-coastal component attains is maximal influence on the West Greenland Current in early summer *(June)*, whereas the warm component is of maximal influence in late autumn (November). Since 1950 time-series of temperature and salinity are regularly collected along the Fylla Bank section. The bulk of the existing temperature and salinity data originates from the Standard Oceanographic Station 4 at 63°53'N,53°22'W (fig. 1), and from the inshore stations 1, 2, 3 of this section (ICNAF Selected Papers No. 3, 1978; STEIN, 1988). During the past decades *anomalous* cold situations have been encountered at West Greenland and in the West Greenland Current system (STEIN and BUCH, 1985a). Due to regional meteorological anomalies strong negative anomalies of temperature and salinity were observed at Station 4/ Fylla Bank, which peaked in 1983. STEIN (1986) noted that the two coldest periods in over 20 years on Fylla Bank occurred in 1972 and 1983, at times when strong El Niño-type events occurred in 2 successive years in the South Pacific Ocean. He suggested that the linkage is through large-scale atmospheric circulation. Analysis on the short time variability in hydrographic conditions off Fylla Bank was done by STEIN and BUCH (1985b). Based on repeated CTD profiles during a 15 hours time station at Station 4 of the Fylla Bank Section, they observed that due to changing wind direction advective processes took place which led to cooling of the upper surface layer (0-30m). This is in correlation with the theoretical value for the depth of frictional influence for a pure drift current (39m at the station site). The influence of the tidal motion is mostly expressed in the deep layers of the water column. STEIN and NESSTORFF (1988) show that warm/saline and cold/diluted periods in the oceanic climate lasted for about 3 to 5 years. A similar periodicity is observed for strong cod year classes up to 1973. In a recent paper BUCH and SLOTH (1988) indicate that the relationship between sea-ice distribution and concentration in the Greenland and Iceland Seas with temperatures at Fylla Bank showed ice-cover in December to be correlated with June temperature, indicating a 6 month travel time. The authors predicted a temperature of 1.5-1.7°C for June 1988 on Fylla Bank. The measured value was close to the predicted one, but slightly higher.

On the basis of long-term records of monthly mean air temperatures at Godthaab/West Greenland and on subsurface temperature data at Fylla Bank west off Godthaab from June and November the hypothesis is tested whether the trend of ocean temperature variation might be deduced from the mean air temperatures.

DATA AND METHODS

Air temperatures of Godthaab, used within the present study, are part of a time series of monthly mean values sampled from 1876 onwards at the Godthaab meteorological station. For correlation with the ocean subsurface temperature data, the last 25 years were taken, thus covering the range from 1963 to 1987. Fylla Bank mid-June temperature data from top of the bank (fig. 2) were sampled by the Greenland Fisheries Research Institute, Copenhagen, whereas the November temperature anomaly data originate from a data set sampled by the Institut fuer Seefischerei, Hamburg, and mutually completed by the Greenland Fisheries Research Institute, Copenhagen (fig. 3). Correlation analysis was performed for each monthly time series. The results of "lag 0" correlation are given in figs. 4 and 5.

RESULTS AND DISCUSSION

Fig. 2 displays the temperature time series of mid-June for the top of the Fylla Bank. It clearly demonstrates that in the past 25 years periods of warm and cold situations were present in the shallow waters of Fylla Bank. Especially the early seventies and early eighties anomalies emerge from the picture. The November data set (fig.3) outlines the anomalous cold early eighties. The late sixties/early seventies indicate anomalous cold temperatures at station 4, but not in the same order of magnitude than a decade later. Correlation between the two ocean temperature time series yields a correlation coefficient of 0.54 at lag 0, indicating that there is positive interrelation between the June and November time series. From fig. 4 and 5 it would appear that correlation between ocean and air temperature time series yields an annual spectrum which peaks in May and August/September for the mid-June data, and August/September for the November data. Correlation coefficients range from +0.19/-0.15 (December) to +0.67 (August)/+0.64 (September) indicating predominantly positive correlation between both kinds of time series. Highest correlation is found for May (+0.63) and August (+0.67) for the mid-June data, and for late summer with the August (+0.57) and September (+0.64) values for the November data.

The correlation spectrum for the mid-June data (fig. 4) might indicate that the air-temperatures in May influence the mid-June ocean temperatures, whereas the August air-temperatures are determined by the thermal history in mid-June. Based on the assumption that late summer air temperatures are indicative for the ocean temperature situation found in November, the time series analysis of air temperatures was continued to the extent of the August/September 1988 data (figs. 6,7). The figures point at a cooling tendency which was already present in the 1987 data of September air and ocean temperatures. However, when RV "Walther Herwig" performed its annual groundfish survey off West Greenland at the end of October/beginning of November, upper ocean temperatures were anomalous warm in the 0-200m layer. In October 1988, the West Greenland area experienced a strong inflow of warm Irminger Water, which is reflected in high temperatures and salinities at Fylla Bank Station 4 from 75m and downwards. Therefore the high ocean temperatures in October are due to advective processes, the surface layer is heated from below. Atmospheric cooling during November affected the same depth range of the upper surface layer and led to temperature anomalies as displayed in fig. 9. However, both data sets, October and November correlate in the same way with the air temperature time series (fig. 5), and thus confirm the predicted trend as statistically indicated from the August/September air temperatures. Air temperature in following months decreased drastically (fig. 10). This confirms the cooling trend as postulated from the upper ocean/late summer air temperature scenario.

Are we facing a new cold epoch off West Greenland?
The January, February 1989 air temperatures suggest this trend. The entire January air temperature time series of Godthaab (fig. 11) indicates from 1876 onwards, a continuous up and down of warm and cold winter periods. It shows the extreme cold anomaly of the early eighties, which is unique in the course of the 114 years time series. Additionally, the most recent trend suggests another cold winter period to come. On the other hand it indicates that an overall warming trend inhabits the January time series. Using a linear model, warming is observed which amounts to 0.03°C/year (fig. 12). Considering the annual spectrum of warming/year, fig. 13 shows that winter months December, January and February stand out as those months of the year where the warming trend is ≥ 0.03°C/year. These values clearly differ from those of the rest of the year which do not exceed 0.01°C/year. It would appear that this warming is due to the so-called "Greenhouse-Effect" which affects the cold season to a considerably larger extent (fig. 13) than the warmer seasons. This overall warming might also be detectable in the ocean temperature time series. However, analysis proves that only for the June situation the comparatively short ocean time series reveals this general warming trend, i.e. +0.004 °C/year (fig. 14). As for the November situation the time-window enables a look on a cooling trend which amounts to -0.01 °C/year (fig. 15). The problem of a reduced time-window is shown in fig. 16 which displays the past 26 years of the Godthaab January time series. From these data it would appear that cooling, instead of the afore revealed warming governs the atmospheric climate of West Greenland during winter season. Especially the anomalous cold temperatures in the early eighties, plus the most recent thermal scenario from January 1989, determine the negative trend visible in the time-window of the past 26 years. Surface temperature data collected during January 1989 on top of the West Greenland fishery banks (SCHOENE, pers. comm.) indicate for the area between 62°50'N and 60°00'N a cooled surface layer which ranges from 0°C to -1°C. Air temperatures at sea were well below -5°C, mostly around -10°C. Cold air was mostly advected by strong gales from northwesterly directions. As analysed by BUCH (1987), the temperature of the surface layer, as well as its interannual variations, are very much dependent on the heat exchange between ocean and atmosphere. During the anomalous cold early eighties a cold air mass was stationary located at Egedesminde/West Greenland. This led to heat loss of the

ocean. The 1989 situation might be influenced in a similar way. Again a stationary cold air mass is situated above the Labrador Sea area, this time, however, off Newfoundland. Off the West Greenland coast the atmospheric cooling led to formation of great amounts of sea-ice during February 1989, in areas which normally are ice free during winter.

CONCLUSIONS

Based on the present data set and its analysis, it would appear that the statistical coherence between air temperature and upper ocean temperatures are a usefull tool to estimate future trends in upper ocean climatic development. Especially the correlation analysis between the November ocean temperature anomaly curve and the air temperatures of August and September which peeks in a very defined time band, yields promising results. With the short-time warming/cooling effect of the wind on the upper frictional layer of the ocean (0-30m) in mind, prediction of ocean surface layer (0-200m) climatic development seems to be possible.

REFERENCES

BUCH, E. 1982. Review of oceanographic conditions in Subarea 0 and 1 during the 1970-79 decade. NAFO Sci.Coun.Studies 5: 43-50.

BUCH, E. 1984. Variations in temperature and salinity of West Greenland waters, 1970-1982. NAFO Sci.Coun.Studies, 7: 39-43.

BUCH, E. 1987. Preliminary considerations on the heat transport in West Greenland waters. NAFO SCR Doc. 87/29, p.

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 1985a. 1983: an unusual year off West Greenland? Arch. FischWiss. 36 (1/2): 81-95.

STEIN, M. and E. BUCH 1985b. Short Time Variability in Hydrographic Conditions off Fyllas Bank, West Greenland. NAFO SCR Doc. 85/30: 7 p.

STEIN, M. 1986. Cold Water off West Greenland - Teleconnection with El Niño? Tropical Ocean-Atmosphere Newsletter 34: 7-8.

STEIN, M. 1988. Revision of list of NAFO standard oceanographic sections and stations. NAFO SCR Doc. 88/01: 9 p.

STEIN, M. and J. MESSTORFF 1988. Are fluctuations in cod recruitment off West Greenland related to long-term variations of the physical environment. NAFO SCR Doc. 88/36: 14 p.

Fig. 1 Location of Fylla Bank Station 4 (triangle) and General Sea Surface Circulation

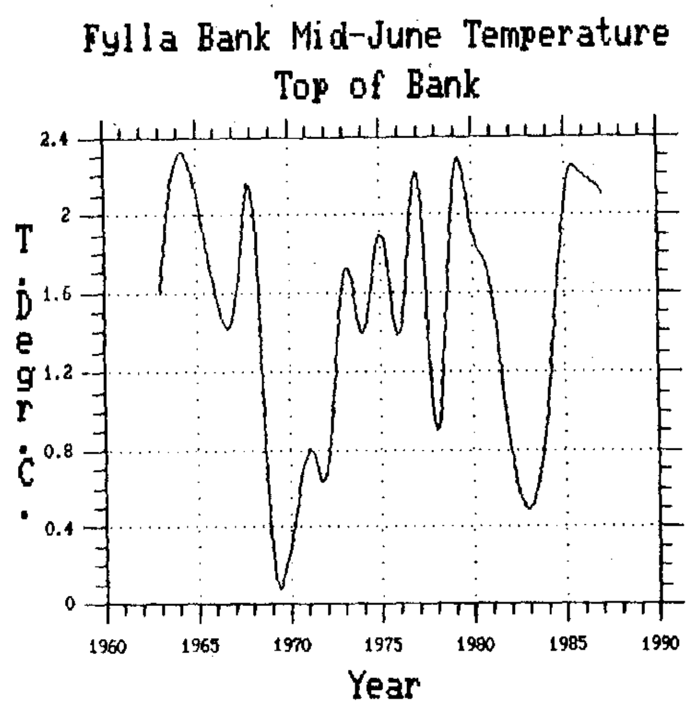

Fig. 2 Smoothed Temperature/Time Series 1963-1987 Top of Fylla Bank, Mid-June

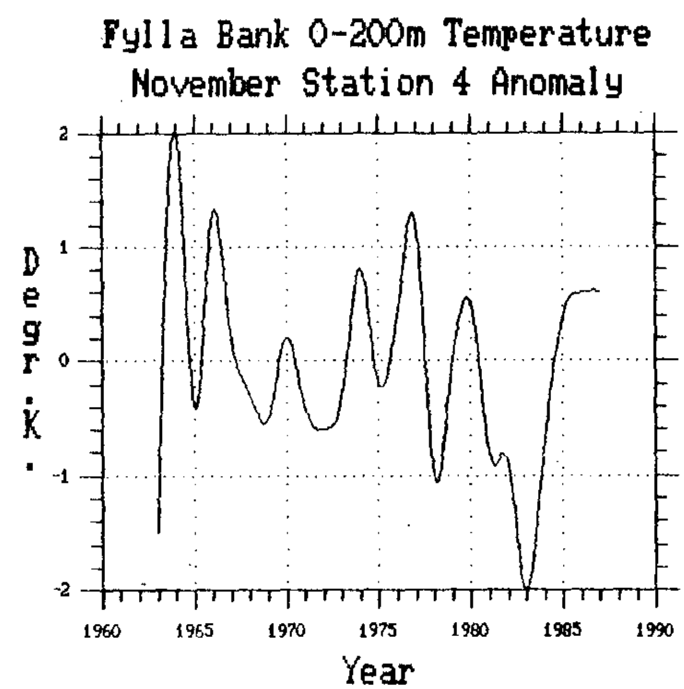

Fig. 3 Smoothed Temperature Anomaly/Time Series 0-200m Layer Station 4 of Fylla Bank Section, 1963-1987

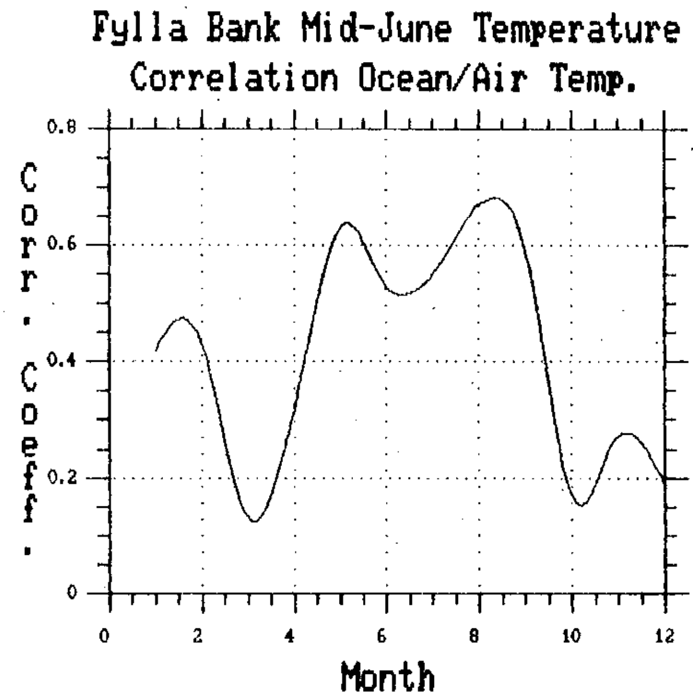

Fig. 4 Correlation Spectrum Fylla Bank Mid-June Temperature versus Godthaab Monthly Mean Air Temperatures

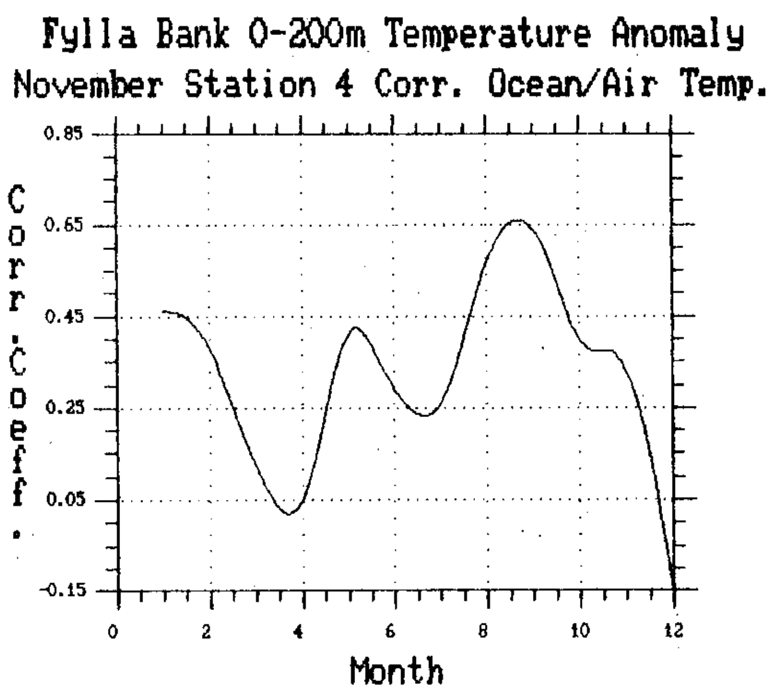

Fig. 5 Correlation Spectrum Fylla Bank 0-200m Temperature Anomaly versus Godthaab Monthly Mean Air Temperatures

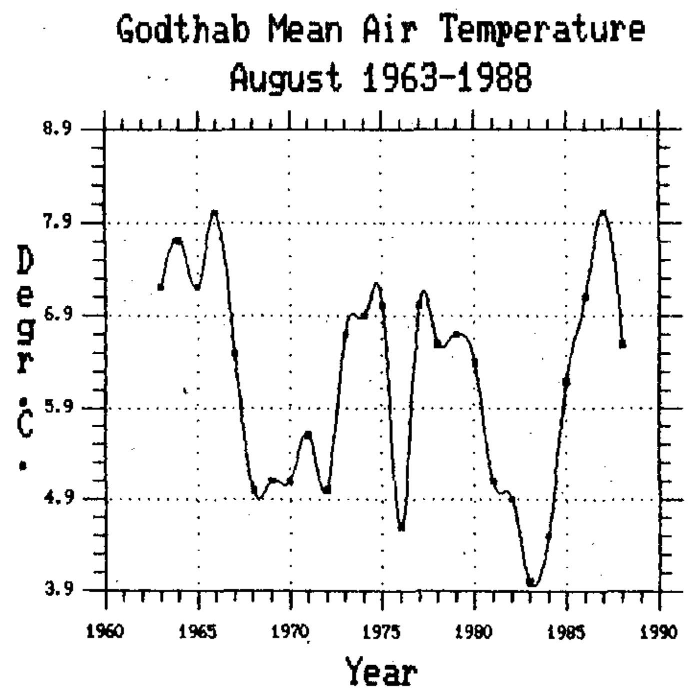

Fig. 6 Godthaab Mean Air Temperature August 1963-1988

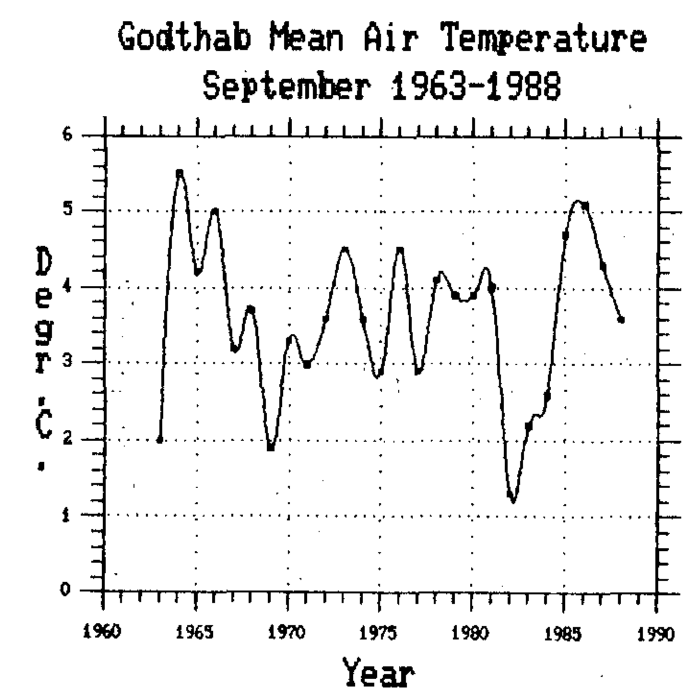

Fig. 7 Godthaab Mean Air Temperature September 1963-1988

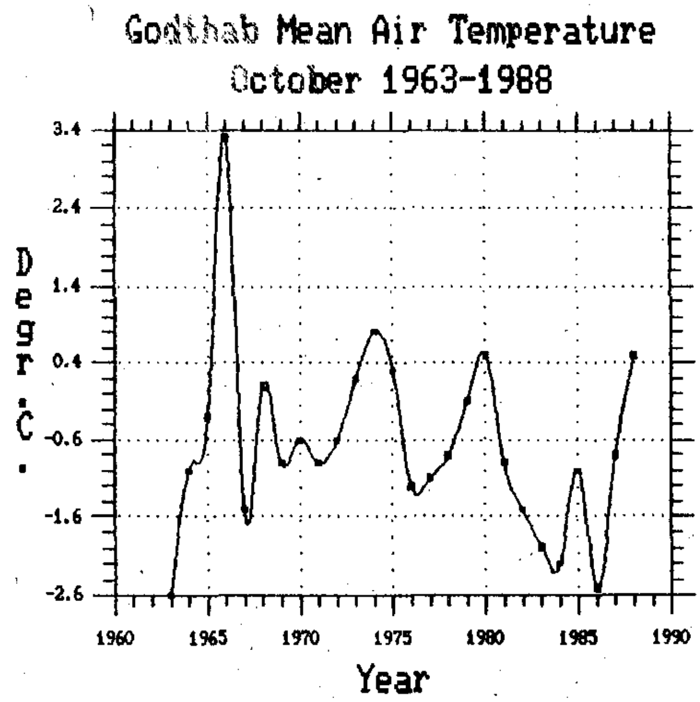

Fig. 8 Godthaab Mean Air Temperature October 1963-1988

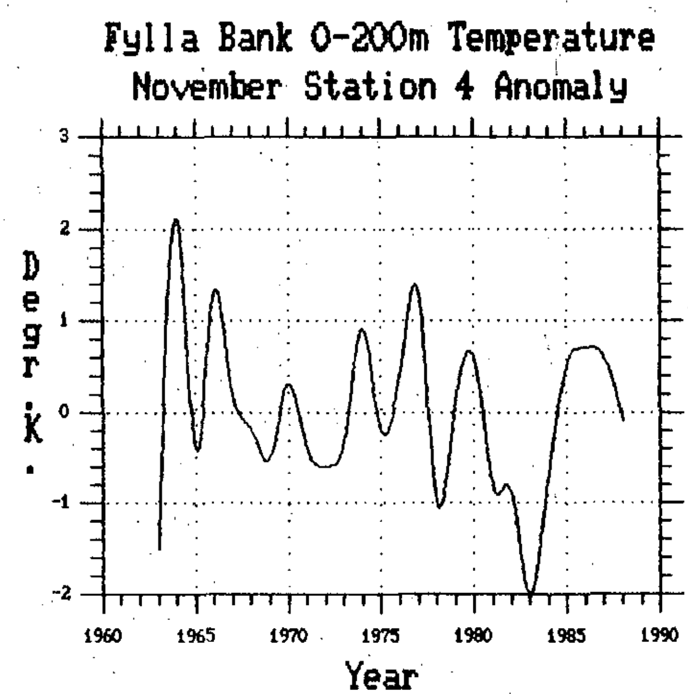

Fig. 9 Smoothed Temperature Anomaly/Time Series 0-200m Layer
Station 4 of Fylla Bank Section, 1963-1988

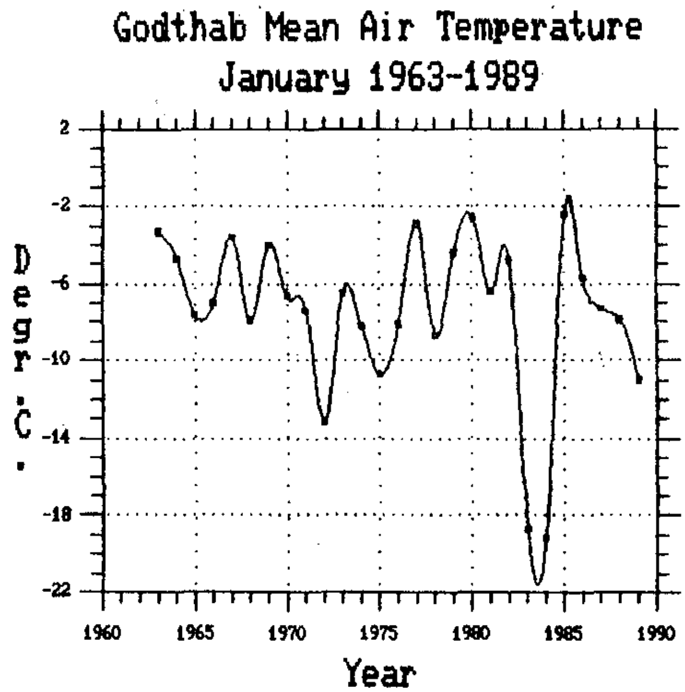

Fig.10 Godthaab Mean Air Temperature January 1963-1989

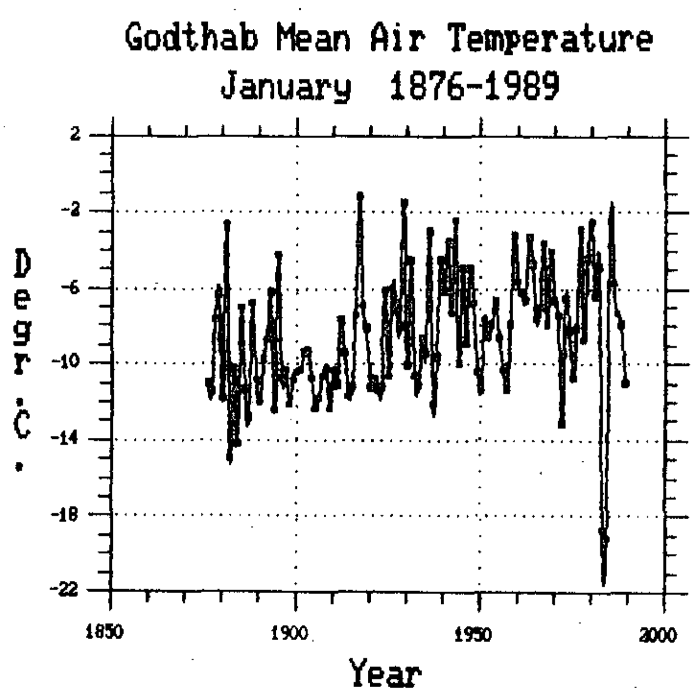

Fig.11 Godthaab Mean Air Temperature January 1876-1989

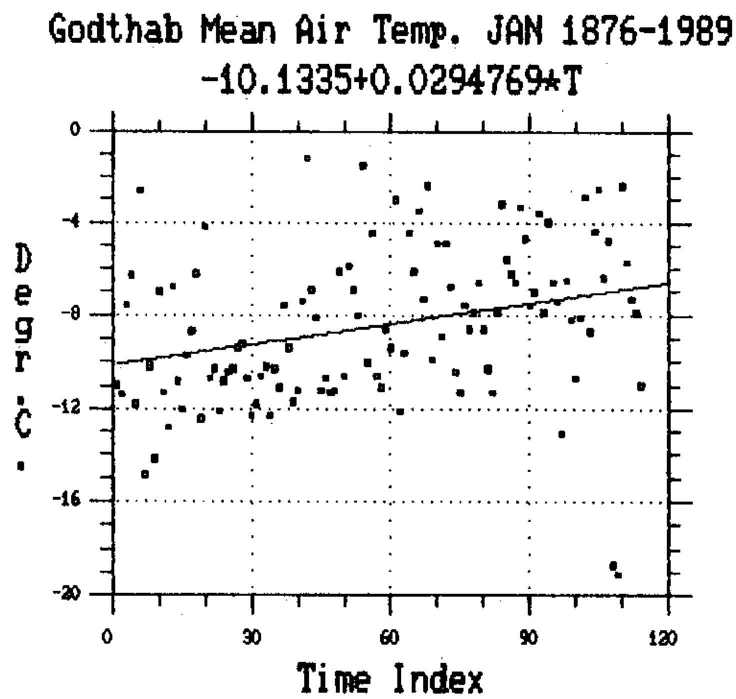

Fig.12 Godthaab Mean Air Temperature January 1876-1989
Linear Trend Analysis

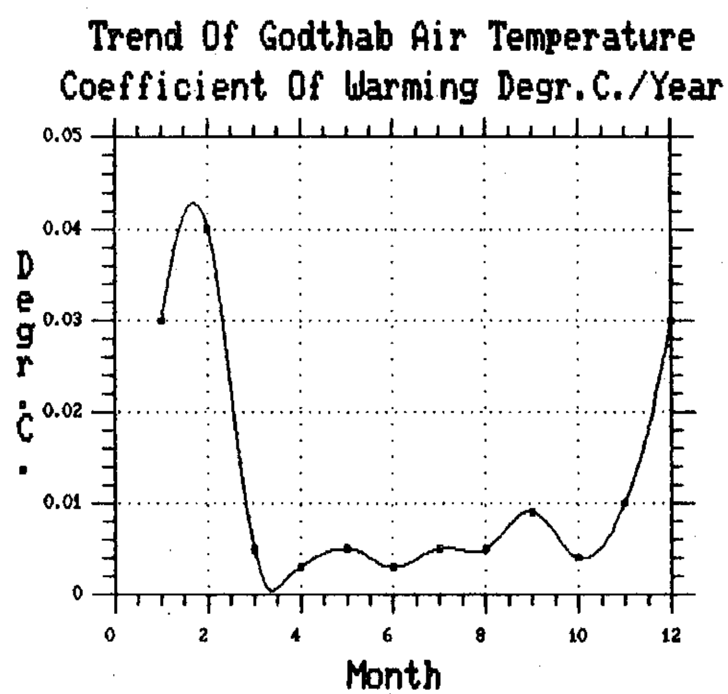

Fig.13 Spectrum of Coefficient of Warming Degr.C./Year
Godthaab Mean Air Temperature 1876-1989

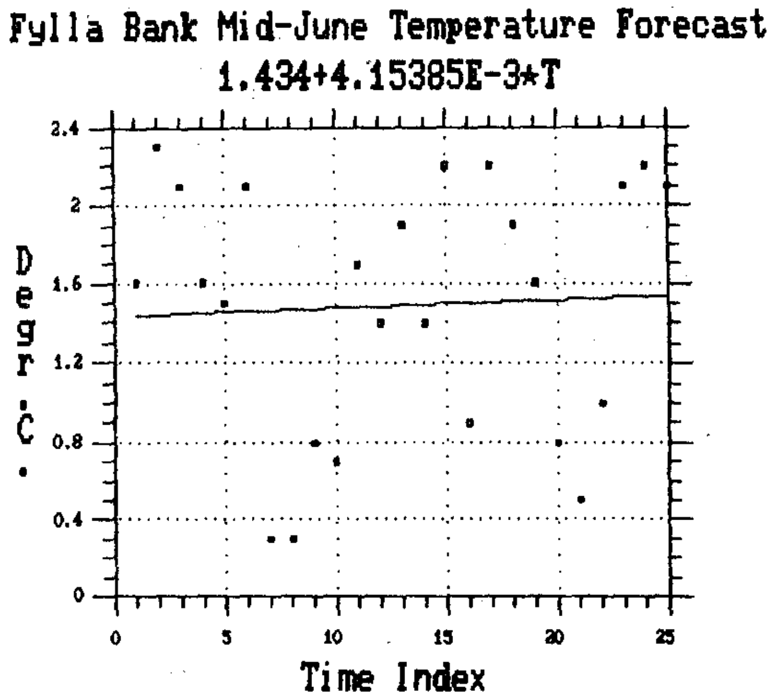

Fig.14 Fylla Bank Mid-June Temperature Linear Trend Analysis

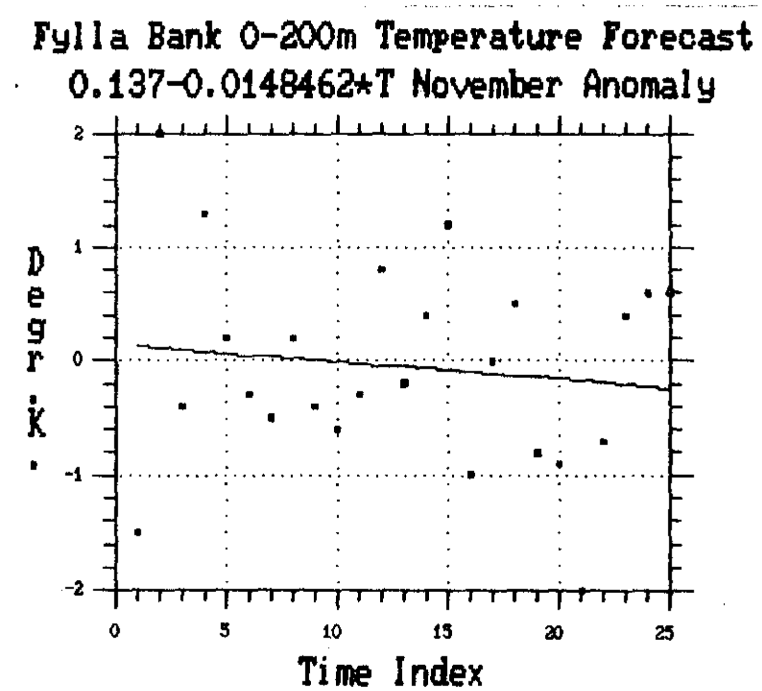

Fig.15 Fylla Bank November Temperature Anomaly Linear Trend Analysis

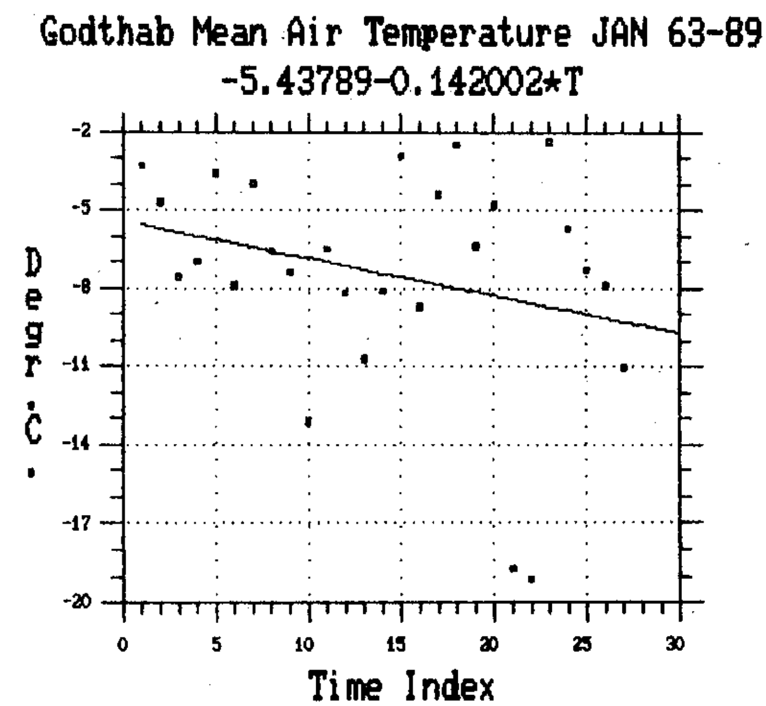

Fig.16 Godthaab Mean Air Temperature January 1963-1989
Linear Trend Analysis