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Recent Variations of Salt and Heat Flow in West Greenland Waters

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Abstract

Short time-series along the deep-water standard oceanographic sections Cape Farewell, Cape Desolation and Frederikshaab are analyzed for changes in the temperature and salinity trends in the surface layer (0–50 m) and in the Irminger layer (200–300 m). The surface layer reveals concurrent signals in both temperature and salinity which indicates the presence of East Greenland type polar water. Data from the subsurface layer indicate increased inflow of Irminger type water to the West Greenland region.

Introduction

West Greenland waters obtain their heat from solar radiation and from the Irminger component of the West Greenland Current system (Buch, 1982; Stein and Buch, MS 1985). Seasonal changes of heat transfer from atmosphere to ocean (and ocean to atmosphere) and changes in the advective component of heat flow into West Greenland waters were considered by Buch (MS 1987) on a theoretical basis, and the core of the Irminger component were described at depths between 200 m and 300 m. Based on a time-series of deep CTD-profiles at NAFO Standard Oceanographic Stations (Stein, MS 1988), the present paper gives an estimate of variation in the advective part of heat input to the West Greenland waters.

Materials and Methods

During the annual autumn groundfish surveys to the waters off West Greenland, the RV *Walther Herwig* worked along NAFO Standard Oceanographic Sections of Cape Farewell, Cape Desolation and Frederikshaab (Fig. 1). All CTD-profiles were obtined with the same device, a regularly calibrated CTD of KIEL-Multisonde type. Water samples were taken by means of a Rosette water sampler at depth intervals of about 500 m below 500 m depth. The CTD temperature readings were checked against reversing thermometers. Salinity was determined with a GUILDLINE-Autosal salinometer. The dataset covered the years 1983 to 1989 with the exception of 1985, when the deep water sections were not performed. The temperature/salinity profiles were reduced to North Atlantic standard-depths data to perform anomaly calculation for the water layers under consideration, i.e. the surface layer (0–50 m) and the Irminger layer 200-300 m. The mean anomaly of these layers was used to plot the variation of heat and salt input to the waters off West Greenland.

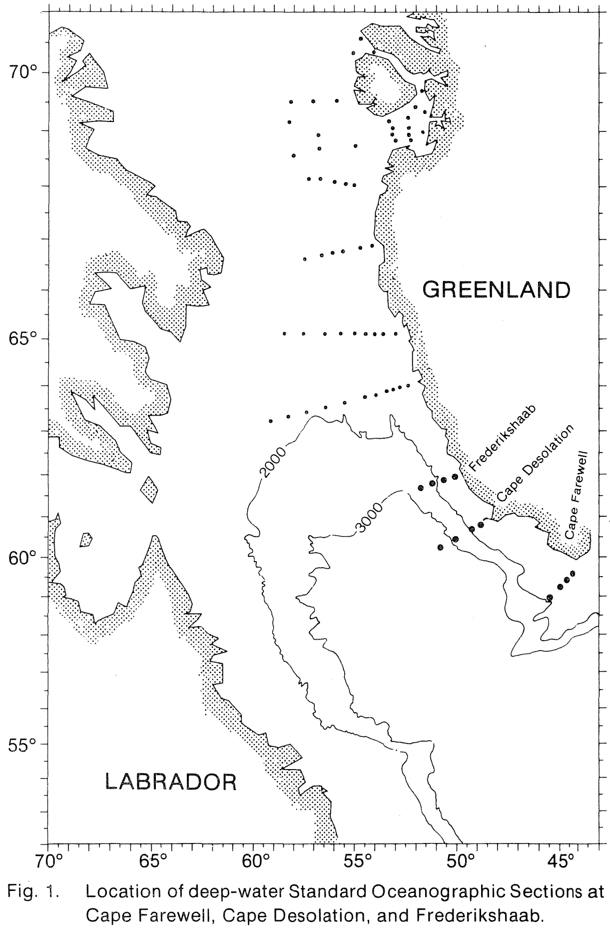

Fig. 1. Location of deep-water Standard Oceanographic Sections at Cape Farewell, Cape Desolation, and Frederikshaab.

Results

The temperature and salinity anomalies are displayed in Fig. 2–5 at individual standard stations along NAFO Standard Oceanographic Sections Cape Farewell (a), Cape Desolation (b), and Frederikshaab (c and d). Numerical results of the anomaly calculation are given in Table 1 for the surface layer (0–50 m), and for the Irminger layer (200–300 m).

Figure 2a indicates surface layer warming at Cape Farewell Station 4. The warming trend which has been apparent since 1984, peaked in 1987-88. From a mean temperature of 5.6°C, the cold period of the early-1980s (Buch and Stein, 1989; Stein and Buch, 1990) deviate by more than 1°K. The Irminger layer at this station also behaved similarly, with positive anomalies since 1987 (Fig. 3a). A completely different thermal trend was recorded at Cape Desolation Station 3 (Fig. 2b, 3b) with positive surface layer anomalies observed from 1984 to 1988, and negative anomalies in the Irminger layer during 1983 and 1989, which were about 0.5°K below the mean value (c.f. Table 1). Further north, at Frederikshaab Bank, the thermal trends at neighbouring Stations 3 and 4, which are about 30 km apart, differed in both layers (Fig. 2c, d and 3c, d). Whereas both stations mapped the cold early-1980s, the interannual change differed considerably from station to station.

TABLE 1. Mean values of temperature and salinity for the surface layer (0–50 m), and for the Irminger layer (200–300 m).

	Temperature (°C)		Salinity (PSU)	
Station	0–50	200–300 m	0–50 m	200–300 m
Cape Farewell, Station 4	5.58	4.70	34.753	34.928
Cape Desolation, Station 3	3.35	4.94	34.157	34.927
Frederikshaab, Station 3	2.46	5.05	33.607	34.840
Frederikshaab, Station 4	3.16	4.92	34.015	34.902

Salinity anomalies indicated similar trends at Cape Farewell Station 4 (Fig. 4a, 5a) in the surface layer and in the Irminger layer. Negative anomalies were observed from 1983 to 1986 which amounted to 0.045 PSU below the mean value in the deeper layer, whereas

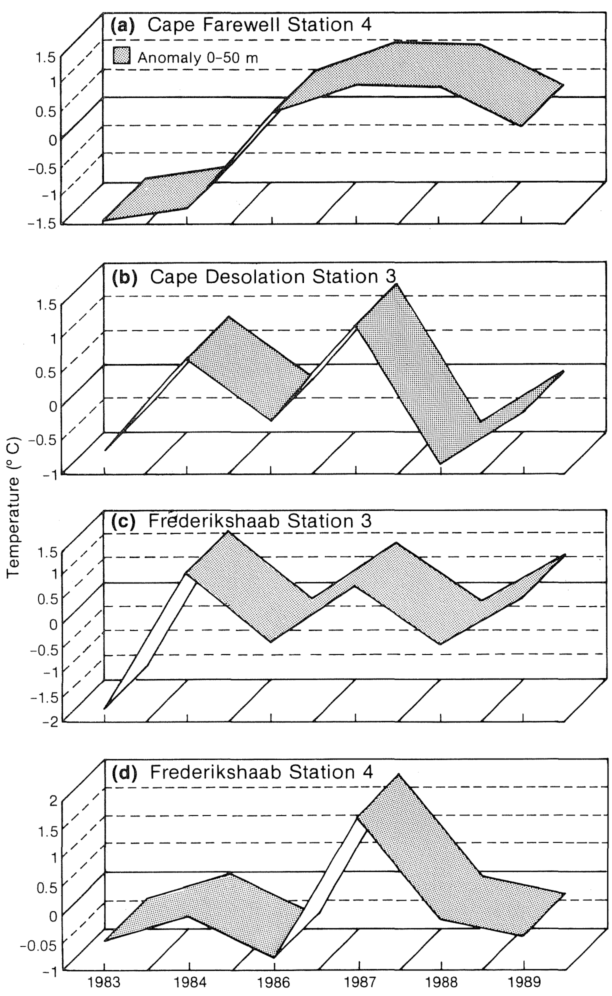

Fig. 2. Surface layer (0–50 m) temperature anomalies at (**a**) Cape Farewell Station 4, (**b**) Cape Desolation Station 3, (**c**) Frederikshaab Station 3 and (**d**) Fredrikshaab Station 4.

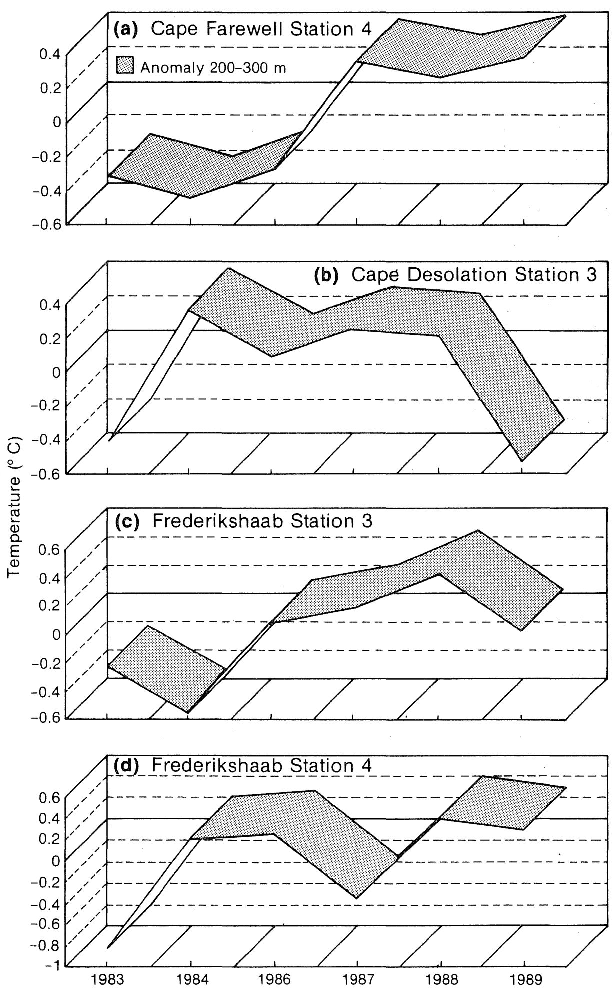

Fig. 3. Irminger layer (200–300 m) temperature anomalies at (**a**) Cape Farewell Station 4, (**b**) Cape Desolation Station 3, (**c**) Frederikshaab Station 3, and (**d**) Fredrikshaab Station 4.

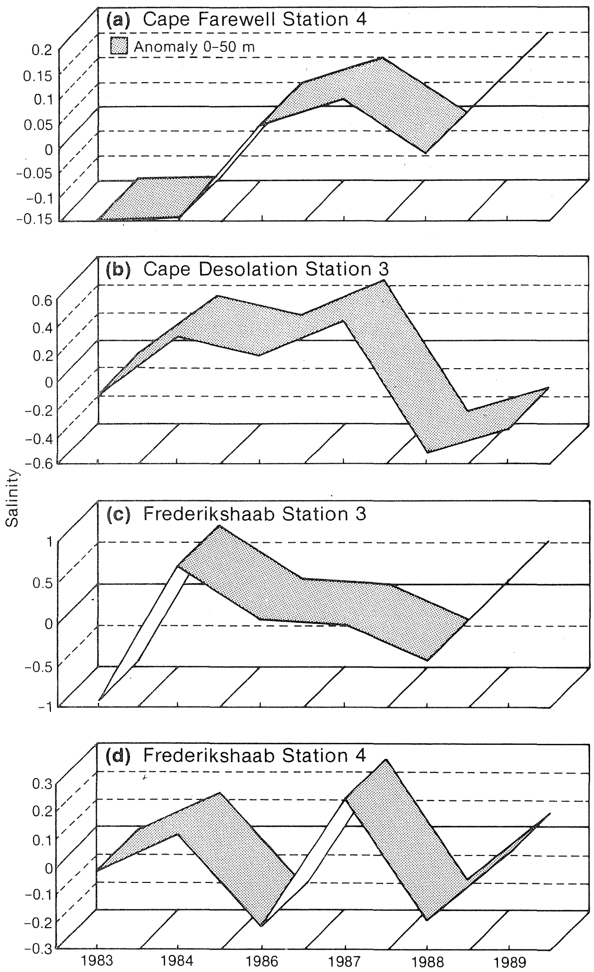

Fig. 4. Surface layer (0–50 m) salinity anomalies at (**a**) Cape Farewell Station 4, (**b**) Cape Desolation Station 3, (**c**) Frederikshaab Station 3 and (**d**) Frederikshaab Station 4.

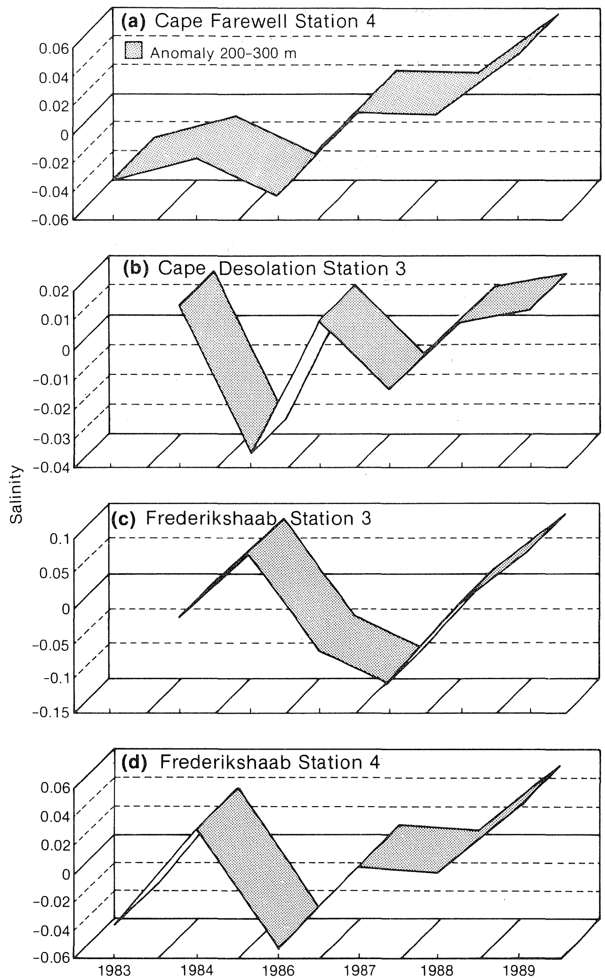

Fig. 5. Irminger layer (200–300 m) salinity anomalies at (**a**) Cape Farewell Station 4, (**b**) Cape Desolation Station 3, (**c**) Frederikshaab Station 3 and (**d**) Fredrikshaab Station 4.

the variability in the surface layer was three times larger in 1983 and 1984 (-0.14 PSU). The cooling trend at Cape Desolation Station 3 was accompanied by low salinities in the surface layer during 1988 and 1989 (Fig. 4b). This trend was, however, not observed in the deeper Irminger layer (Fig. 5b) which in fact indicated a slight increase in salinity anomaly at about 0.02 PSU. It appears that this surface layer signal originates from increased transport of icebergs from East Greenland to the area of Julianehaab Bight, as observed during 1989. At Frederikshaab Bank Stations 3 and 4 the surface salinity trends followed the thermal trends (Fig. 4c, d) and the Irminger layers indicated increase in salinity by as much as 0.09 PSU (Fig. 5c) and 0.05 PSU (Fig. 5d).

Discussion

It appears that the surface layer (0–50 m) in this region is affected by the trends in temperature and salinity in a similar way: cooling is accompanied by dilution of the surface waters. This might reflect that the surface layer is mostly influenced by the "cooling" and "diluting" factors of this region, i.e. the occurrence of ice, and the regime of the cold East Greenland component of the West Greenland Current system. Observations at especially Cape Desolation Station 3 reveals that there was injection of cold and diluted polar water of East Greenland origin in 1988 and 1989. During the 1989 autumn season there were anomalous amounts of icebergs in the southwest sector off West Greenland with a distinct cut-off in the distribution of icebergs south of Frederikshaab glacier. However, wind-induced lateral shifting of water mass boundaries, which occur on time-scales of hours, may also lead to these observed interannual changes (Stein and Buch, 1985; Stein, MS 1989).

In the Irminger layer (200–300 m), only at the southern boarder of the West Greenland region was there a similar trend in both the thermal and the haline signals. It indicated an increased inflow of Irminger water to the West Greenland waters. Although the remainder of the stations indicated positive anomalies for the years 1988 and 1989, both signals behaved differently.

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