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Persistent cold climatic episodes around Greenland and Baffin Island: Links to decadal-scale sea surface temperature anomalies

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Abstract. Two unusually persistent cold episodes around Greenland and Baffin Island in 1971-1972 and 1982-1984 are described in terms of their severity, atmospheric circulation variability, and changes in sea surface conditions. The episodes are significant due to the sizeable station temperature departures, many exceeding one standard deviation, and their persistence. In both episodes unusually persistent cold pools of water developed in the northern Atlantic and intensified near Davis Strait close to the onset of the cold climatic events and then migrated out of the region as the episodes came to a close. Anomalous northerly surface air flow occurs in most months during the two episodes.

Introduction

This paper describes and compares two episodes of persistent cold that took place around Baffin Bay in the northwestern Atlantic, affecting settlements on western Greenland and eastern Baffin Island (Figure 1). The first cold episode extended over a 13 month period, December 1971 through 1972, but the more significant event was 33 months from February 1982 through October 1984. These persistent cold climatic episodes occurred during recent decades dominated by comparatively cold northern subpolar oceans [*Jones*, 1988; *Wallace* et al, 1996] and we show that they are associated with persistent northerly flow and that they may be initiated and ended by migration of specific decadal-scale sea surface temperature anomalies (SSTA) in and out of this relatively confined region. Atlantic SSTAs vary on decadal time scales [*Deser and Blackmon*, 1993; *Kushnir*, 1994; *Hansen and Bezdek*, 1996, *Reverdin* et al, 1997], occasionally moving along well-defined paths [*Sutton and Allen*, 1997] potentially linked to the Atlantic thermohaline circulation. The two climatic episodes discussed here contribute to growing evidence of associations between decadal-scale SSTAs and climatic variability [*Latif and Barnett*, 1996; *Shabbar* et al, 1997].

Data include monthly coastal air temperatures, for sites in Figure 1, from the World Monthly Surface Station Climatology. Monthly air temperature departures are normalized using the standard deviation about the mean. Monthly sea level pressures and 500 hPa heights, available for a 5° x 5° grid over the Northern Hemisphere, are used in making estimates of the meridional component of the geostrophic wind across Davis Strait. Global monthly SSTA data [*Kaplan* et al, 1997] are available on a 5° x 5° grid, extending to 60°N latitude around Greenland, from 1856-1991. The Kaplan gridded monthly SSTAs are normalized by their standard deviations and filtered using a low-pass filter [*Trenberth*, 1980] emphasizing periodicities beyond 4 years. Nimbus-7 Scanning Multichannel Microwave radiometer (SMMR) derived daily mean total sea ice concentrations [*Gloersen* et al, 1992], available on a 25 x 25 km grid, are presented for days near the end of Januaries 1979 and 1983.

Results

Table 1 summarizes persistence characteristics of the two Baffin Bay cold episodes. At Egedesminde, Greenland (see Table 1 and Figure 2a) all but one of 33 months in the 1982-1984 episode had below normal air temperatures (from 1951-1990 means); 29 of them occurred consecutively, and 23 months were more than one standard deviation below normal. Normalized monthly air temperature anomalies for Godthåb and Prins Christian Sund (Table 1, Figures 2b-2c) exceed one standard deviation in 24 and 18 months, respectively, but long consecutive streaks of subnormal air temperatures are broken by small positive temperature departures in one or two months during 1983. Eastern Baffin Island was not as severely cold as western Greenland (Table 1). Broughton Island (Figure 2d) overall had 28 months of subnormal mean air temperatures but only 12 were one standard deviation below normal and Cape Dyer, Cape Hooper (Figure 2f), Iqaluit (Figure 2e), and Clyde each had temperature anomalies below one standard deviation in 10 or 11 months. The coldest period on Baffin Island was concentrated over 21 months from September 1982 through May 1984.

The 1971-72 cold episode occurred primarily in a thirteen month period from December 1971 through calendar 1972 (Figure 2). Compared to the 1982-1984 event, this episode exhibits lower standardized temperature departures at Baffin Island sites (see Figures 2d-2f) and those farther south such as Hopedale and Cartwright (south

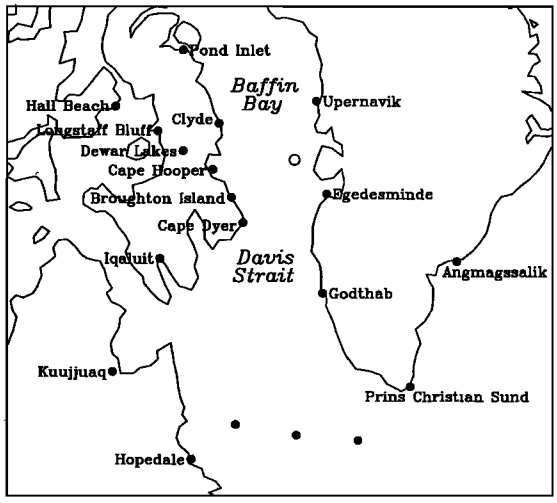

Figure 1. The study area giving locations of climatological stations used in Table 1. The northerly wind component (Figure 3) is calculated at the open circle and averaged filtered standardized SSTAs are averaged at the three dots for Figure 6.

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Table 1. Number of months from February 1982 through October 1984 (33 months) and from December 1971 through December 1972 (13 months) in which air temperatures were below normal (column 1) and less than or equal to one standard deviation below normal at stations around Greenland and Baffin Island in Figure 1.

	NUMBER OF MONTHS...			
	1982-1984		1971-1972	
	below normal	≤ -1 St. Dev.	below normal	≤ -1 St. Dev.
Egedesminde	32	23	11	8
Godthåb	31	24	11	6
Prins Christian Sund	31	18	12	9
Angmagssalik	27	11	10	5
Broughton Island	28	12	13	9
Cape Dyer	28	10	12	8
Cape Hooper	27	10	12	9
Iqaluit	27	11	13	11
Clyde	26	10	13	8
Dewar Lakes	23	8	12	7
Longstaff Bluff	22	7	13	10
Hall Beach	18	7	13	10
Hopedale	25	8	13	11
Cartwright	24	8	13	11
Upernavik and Pond Inlet (no data available)				

of Hopedale). Below normal temperatures occur in all 13 months at seven stations (Table 1) with anomalies below one standard deviation during 8 to 11 months at each. West Greenland sites (Figures 2a-2c) are not as comparatively cold as on Baffin Island but have anomalies below one standard deviation in at least six months.

The surface meridional (v) component of the geostrophic wind, calculated at 70°N, 57.5°W (over Baffin Bay), exhibits an anomalous northerly component throughout both events. Departures of monthly meridional wind velocities from a 1951-1990 mean (Figure 3) are negative in all but four months between February 1982 and October 1984, indicating stronger than normal northerly flow, and in 10 of 13 months in the 1971-72 episode. The anomalous northerly flow is generally due to an unusually deep Icelandic low over the Denmark Strait, and a deep trough extending from it northeastward across the Norwegian and Barents Seas. Mid-tropospheric (500 hPa) winds however, have an anomalous northerly component in only 6 of 13 months during 1971-72 and 20 months in 1982-84 at the same grid point, indicating lower persistence of the flow regime above the surface layer.

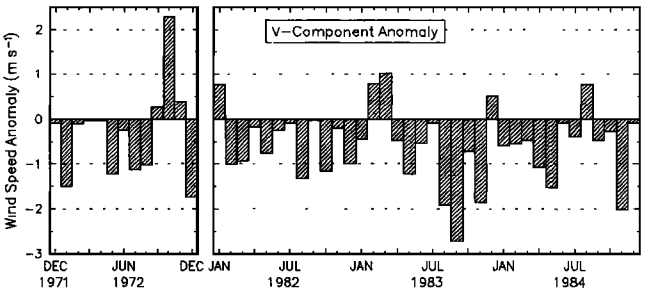

Figure 3. Departures of the meridional v-component of the geostrophic wind, in ms^{-1}, at 70°N, 57.5°W (Baffin Bay). Negative departures indicate that winds are anomalously strong from the north.

SMMR total sea ice concentrations are best exemplified by comparing data for January 1979 and 1983. Open water in Davis Strait extends nearly to 68°N in the milder January 1979 (Figure 4), but ice cover extends southward to the southern tip of Greenland in January 1983 (Figure 4) and 1984. Ice was anomalously far south as early as March 1982 (not shown) and sea ice conditions by January 1985, just after the end of the cold episode, are similar to those of 1979 (see Appendix A.17 of *Gloersen* et al [1992] for a full set of ice extent maps).

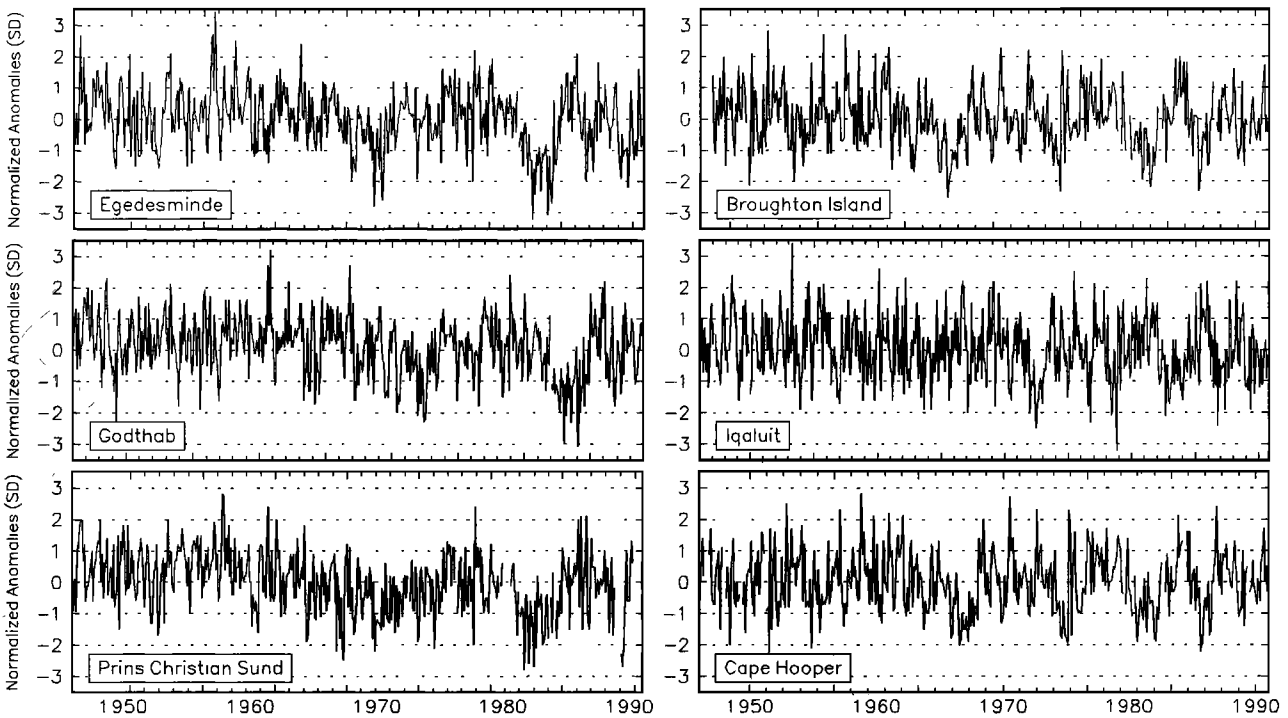

Figure 2. Time series of standardized monthly mean air temperature anomalies for the six stations best exhibiting the persistent cold of the 1982-1984 episode. Units are standard deviations.

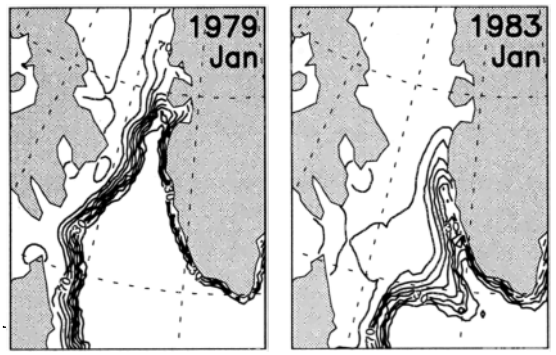

Figure 4. Nimbus-7 SMMR mean total ice concentrations for days near the end of Januaries 1979 and 1983.

A slow-moving cold pool of water spreads westward across the Atlantic through 1981 (Figure 5). Water colder than 0.5 standard deviation reaches Davis Strait by January 1982, and we may infer by extrapolation that it extends northward into Baffin Bay from 1982-1984. Departures two standard deviations below normal lie in eastern Davis Strait by July 1982 and continue to spread across the northernmost Atlantic through 1983. Water colder than 2.5 deviations occurs across both sides of the southern tip of Greenland during 1984. The lowest departures subsequently retreat to the southeast by January 1985, when air temperatures and ice cover return to normal, and relatively warm water has replaced cold in Davis Strait by July 1985. Low-pass filtered Davis Strait SSTAs (Figure 6) are below one standard deviation for much of 1982-1984.

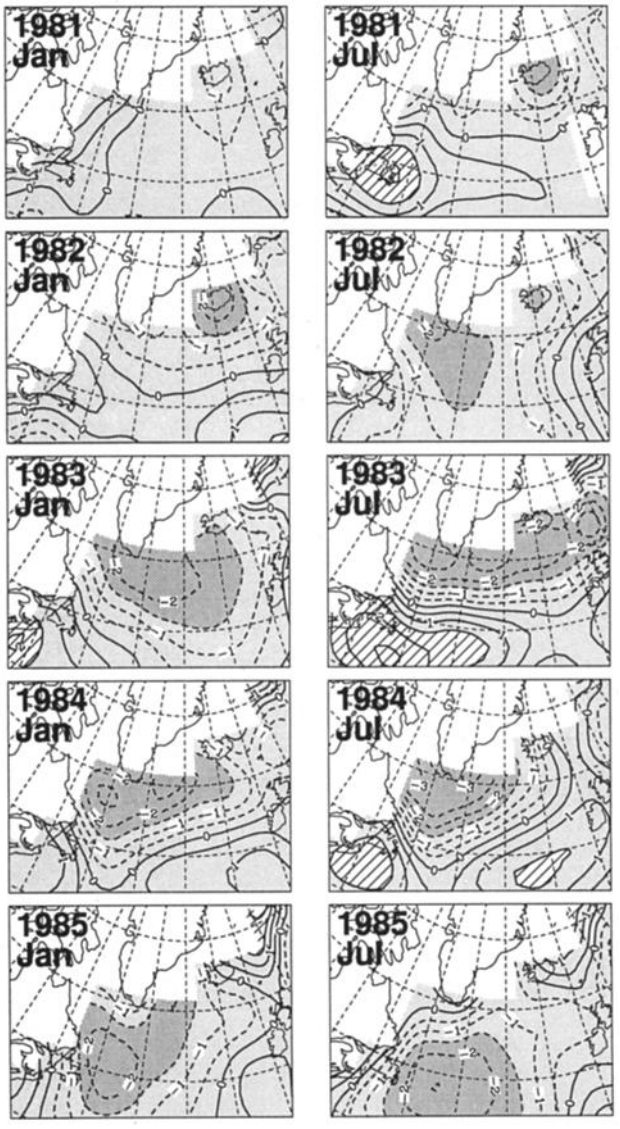

Figure 5. January and July maps of low-pass filtered and standardized monthly sea surface temperature anomalies for 1981-1985. Units are standard deviations. Darkest shading covers areas 1.5 standard deviations below mean temperature while diagonal lines are above the mean by 1.5 standard deviations.

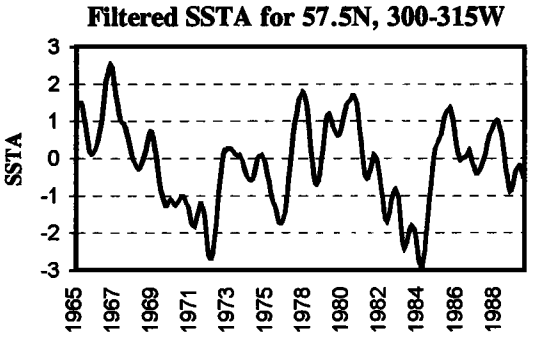

Figure 6. Time series of monthly low-pass filtered and standardized sea surface temperature anomalies (°C) averaged over three grid points at 47.5 to 57.5°W along 57.5°N, 1965-1990.

Below normal Davis Strait SSTAs exceed 1.5 standard deviations as early as July 1971 (Figure 7). They reach a minimum of about 2 deviations by January 1972 and over 3 deviations by July of 1972 in an area just south of the southern tip of Greenland. The coldest water migrates eastward by January 1973. Filtered SSTAs have minima similar to those of 1982-1984 (Figure 6), reaching their lowest values briefly in summer 1972.

Concluding Discussion

The air temperature time series for western Greenland (Figures 2a-2c), especially Egedesminde, appear to exhibit an excursion to a lower climatic mean state during the 1982-1984 episode. One standard

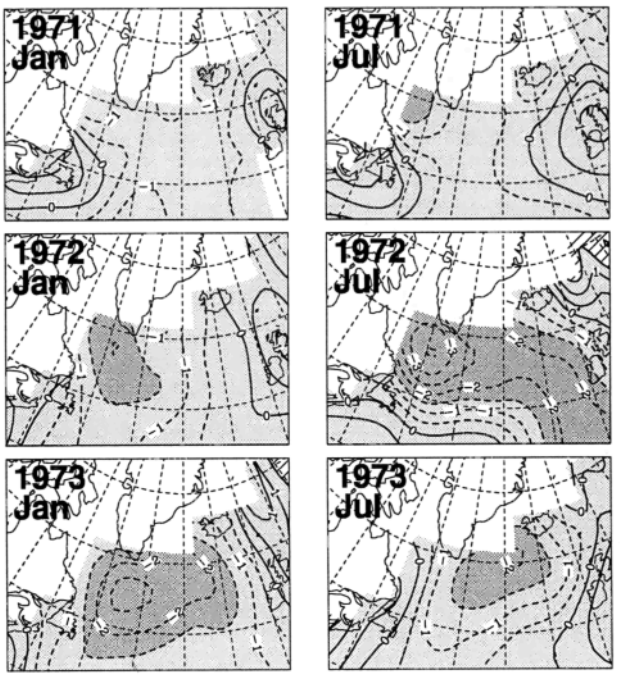

Figure 7. Same as Figure 5 but for 1971-1973.

deviation in winter months represents a 4-6°C temperature decrease at Egedesminde and about 1.2°C in summer months. Filtered SSTAs, along with Jakobshavn, Greenland (near Egedesminde) air temperatures, suggest that an event similar to 1982-1984 occurred in the 1860s. The 1982-1984 episode has also been noticed as a possible analogy for climate change in earlier centuries [*Barlow* et al, 1997]. The harsh conditions of summer 1984, noted by field researchers (Thomas McGovern, 1998; personal communication), included surface snow lasting into June in areas inland of Godthåb, restriction of grass growth until summer, and dense pack ice obstructing local Greenland fiords into July. *Bradley* [1973] first noted a climatic deterioration around Baffin Island in 1971-1973 and *Jacobs* et al [1974] report on the strong northerly flow of summer 1972 (see Figure 3) that maintained snow cover and coastal fast ice along eastern Baffin Island through that summer. Ice conditions were "the worst in living memory of the Eskimo population of Broughton Island" [*Jacobs* et al, 1974; page 68]. Cold water may have penetrated farther north into Davis Strait in 1982-1984, as compared to 1971-1972. This is suggested by *Hansen and Bezdek's* [1996] Figure 4 showing a large, well-established temporally and spatially filtered decadal-scale cold SSTA in the Davis Strait during Januaries 1983 and 1984. In January 1972 (and 1973) however, their analysis only detects a cold feature near the southern tip of Greenland, much in keeping with our results (Figure 7) and suggesting less significant penetration of cold water between west Greenland and Baffin Island.

Our results suggest a close relation between the movement and persistence of decadal-scale subnormal SSTAs into Davis Strait and unusually persistent cold climatic episodes at surrounding coastal areas. It is difficult to tell from filtered SSTAs whether the ocean anomalies lead those of the atmosphere or vice versa. Nonetheless the considerable persistence in both fields, and those of the surface winds, is noteworthy. The fact that mid-tropospheric winds are not as persistent as those at the surface hints at possible feedbacks from the SSTAs to the atmosphere rather than large-scale controls aloft. The persistent regional northerly flow developing with cold SSTAs suggests that intensified low pressure near Iceland and Greenland accompanies periods when northern Atlantic water is colder than one standard deviation. More cases (cold and warm anomalies) are needed to evaluate how low-frequency SSTAs, air temperatures and the atmospheric circulation interact in the Davis Strait/Baffin Bay region.

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