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Overview of Meteorological and Sea Ice Conditions off Eastern Canada during 1995

by

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ABSTRACT

A review of meteorological and sea ice conditions off eastern Canada during 1995 is presented. Annual air temperatures were near normal or above normal due to warm conditions during the spring, summer and autumn. This is in contrast to the cold conditions of recent years. Seasonally, the winter temperature anomalies were below normal but were not as cold as 1994 or the earlier 1990s. The cold air temperatures in winter are related to stronger northwest winds which carried Arctic air masses further south. The stronger winds resulted from an intensification of the Icelandic Low which was reflected in a high NAO index. The colder-than-normal winter air temperatures and accompanying stronger-than-normal northwest winds caused ice to form early, be of greater areal extent than normal and last longer off Newfoundland and southern Labrador. In addition, there were large numbers of icebergs reaching the Grand Banks in 1995, however, both ice extent and numbers of icebergs were less than observed last year. Ice in the Gulf of St. Lawrence and on the Scotian Shelf generally appeared late and, in at least the northern half of the Gulf, left late. The extreme warming of the air over Davis Strait and Baffin Bay during the autumn was due to increased southerly winds associated with a high that developed over Greenland. In general, the moderating conditions from the very cold period of the early 1990s in northern areas that began last year have continued through 1995.

RÉSUMÉ

Un examen des conditions météorologiques et des glaces de mer en milieu hauturier dans l'est du Canada, en 1995, est présenté. Pendant l'année, les températures de l'air étaient près de la normale ou supérieures à la normale à cause du temps doux observé au printemps, en été et en automne. Cette situation fait contraste avec les conditions froides des dernières années. Du point de vue saisonnier, les anomalies de température pendant l'hiver ont été inférieures à la normale sans être aussi froides qu'en 1994 ou qu'au début des années 1990. En hiver, les températures de l'air peu élevées sont attribuables aux vents du nord-est plus forts qui ont transporté des masses d'air arctique plus bas vers le sud. Les vents plus forts sont attribuables à une intensification de la dépression islandaise, comme l'indique un indice OAN élevé. À cause des températures de l'air en hiver inférieures à la normale et des vents du nord-ouest plus forts que la normale qui les ont accompagnées, la glace s'est formée tôt, s'est étendue sur une superficie plus grande que d'habitude et est restée plus longtemps au large de Terre-Neuve et du sud du Labrador. En outre, de grands nombres d'icebergs ont atteint les Grands Bancs en 1995; cependant, l'étendue de la glace de même que le nombre d'icebergs n'étaient pas aussi grands que l'année précédente. En règle générale, dans le golfe du Saint-Laurent et sur la plate-forme Scotian, la glace s'est formée tard et, du moins dans la moitié nord du golfe, elle est aussi partie tard. Le réchauffement extrême de l'air au-dessus du détroit de Davis et de la baie de Baffin, pendant l'automne, était attribuable à des vents du sud plus forts associés à une zone de haute pression au-dessus du Groenland. Dans l'ensemble, les conditions favorables à un adoucissement des températures, comparativement à la période de très grand froid au début des années 1990 dans les zones septentrionales, qui se font sentir depuis 1994 se sont maintenues tout au long de 1995.

INTRODUCTION

This paper examines the meteorological and sea ice conditions off eastern Canada (Fig. 1) during 1995. Specifically, it discusses air temperature trends, atmospheric sea level pressures and associated winds, sea ice coverage and iceberg drift. It compliments the oceanographic reviews of the Newfoundland, Gulf of St. Lawrence and Scotia-Fundy regions, which together constitute the annual environmental overview to the Fisheries Oceanography Committee. Environmental conditions are compared with those of the preceding year as well as the long-term means and expressed as anomalies, i.e. deviations from their long-term mean. Where possible, the latter have been standardized to a 30-yr (1961-90) base period in accordance with the convention of the World Meteorological Organization.

METEOROLOGICAL OBSERVATIONS

Air Temperatures

The German Weather Service, Deutscher Wetterierst, in Offenbach, Germany, publishes monthly mean temperature anomalies (relative to 1961-90) for North Atlantic Ocean in their publication *Die Grosswetterlagen Europas*. During the first three months of the year, colder-than-normal air temperatures were observed over the Labrador Sea and northern Newfoundland regions (Fig. 1). Anomalies were typically -2 to -3°C and even colder along the west coast of Greenland. These conditions contrast with those over the Scotian Shelf and Gulf of Maine where winter temperatures were generally warmer-than-normal. In January, anomalies of 3-5°C were observed over most of this region. The Gulf of St. Lawrence was also warmer-than-normal in winter except February when anomalies were -1 to -2°C. For the months April to November, air temperatures over the Labrador Sea were typically above normal. Exceptions included the southern Labrador Sea and northern Newfoundland during June and July. In November, high positive temperature anomalies (2-7°C) persisted over Davis Strait and Baffin Bay. Around the Maritime Provinces, air temperatures oscillated about normal through April to September. The most significant anomaly was observed in October when air temperatures were 2-3°C above normal although by November, they had dropped back to near normal.

Monthly air temperature anomalies for 1994 and 1995 relative to their 1961-90 means at Godthaab in Greenland, Iqaluit on Baffin Island, Cartwright on the Labrador coast, St. John's in Newfoundland, Magdalen Islands in the Gulf of St. Lawrence and Sable Island on the Scotian Shelf (see Fig. 2 for locations) are shown in Fig. 3. No December data were available for the Magdalen Islands. The predominance of colder-than-normal air temperatures in the first three months of 1995 and generally warmer-than-normal during the rest of the year is evident around the Labrador Sea from Godthaab to St. John's. Wintertime temperatures were more severe than in 1994 at Godthaab but elsewhere they were similar to or less severe than in 1994. The warming in the latter part of the year is most noticeable at Iqaluit.

The time series of temperatures (25-month running means) for the six sites show warming in 1995 and a continuation of the upward trend that began last year (Fig. 4). Note that the interannual variability since 1970 at Godthaab, Iqaluit, Cartwright, and, to a lesser extent, St. John's have been dominated by large amplitude fluctuations with periods of 5-10 yr with minima in the early 1970s, early to mid-1980s and the early 1990s. Indeed, the recent rise in temperature is consistent with a continuation of this decadal pattern. In addition, there has also been an overall downward trend causing temperature anomalies since 1970 to be predominantly below normal. Temperature anomalies at the Magdalen Islands and Sable Island have been of much lower amplitude and show no signs of a general downward trend since 1970. They do, however, contain minima in the early 1970s (both sites), the mid-1980s (Sable Island only) and in the 1990s (Magdalen Islands only).

Iqaluit recorded an annual mean temperature of 8.1°C which represents an anomaly of 1.5°C above normal. This represents a rise of 1.6°C over last year and 4.4°C from 1993. At the remaining five sites, annual air temperatures were within 0.5°C of their long-term mean values and, except for Sable Island, rose relative to last year by between 0.02° to 0.7°C. At Sable Island, temperatures fell by approximately 0.7°C compared to 1994. (Note that at the Magdalen Islands, the average anomaly over the first eleven months was assumed to be representative of the annual average).

Sea Surface Air Pressures

Climatic conditions in the Labrador Sea area are closely linked to the large-scale pressure patterns and atmospheric circulation. Monthly mean sea-surface pressures over the North Atlantic are published in *Die Grosswetterlagen Europas*. The long-term seasonal mean pressure patterns are dominated by the Icelandic Low centred between Greenland and Iceland and the Bermuda-Azores High centred between Florida and northern Africa (Thompson and Hazen, 1983). The strengths of the Low and High vary seasonally from a winter maximum to a summer minimum. Seasonal anomalies of the sea-surface pressure for 1995, relative to the 1961-90 means, are shown in Fig. 5. Winter includes December 1994 to February 1995, spring is March to May, summer is June to August and autumn is September to November.

In winter, negative air pressure anomalies covered the northern North Atlantic a minimum (exceeding -13 mb) centred over the Norwegian Sea due to an intensification and northeastward extension of the Iceland Low. In contrast, a center of positive anomalies (maximum of 6.1 mb) was observed over the southeastern North Atlantic, indicating a strengthening of the Bermuda-Azores High and a shift eastward. A weak anomalous high pressure system also formed over northern Quebec. The resultant air pressure patterns would have strengthened the westerly winds in the eastern sections of the North Atlantic. The northerly winds over East Greenland should have been much stronger-than-normal and may have contributed to an increased transport of both the East Greenland Current and ice out of the Arctic into the Greenland Sea. North winds over Baffin Bay and the Labrador Sea would have been slightly stronger-than-usual while anomalous winds in winter over Newfoundland, the Gulf of St. Lawrence and the Scotian Shelf/Gulf of Maine would have been more northeasterly. In spring a strong positive anomaly developed over Greenland (maximum anomaly of 7.6 mb) while negative centres appeared in the central region of the North Atlantic and over Europe. The winds from these systems would have generated mainly northeasterlies over the regions south of the southern Labrador Sea and southerly winds over Davis Strait and Baffin Bay. In summer a relatively strong low developed east of Newfoundland with a maximum pressure anomaly of -5.5 mb. This would contribute to weaker southerly and southwesterly winds than usual. Similar to the summer, a high positive anomaly (maximum +9.8 mb) developed over Greenland in the autumn. This, together with the low pressure over eastern Canada would have brought more southerly and southwesterly winds than normal to eastern Canada, the Labrador Sea and Baffin Bay. The southerly wind contributed to the above normal air temperatures in the autumn in the Davis Strait and Baffin Bay regions.

NAO Index

The North Atlantic Oscillation (NAO) Index is the difference in winter (December, January and February) sea level pressures between the Azores and Iceland and is a measure of the strength of the winter westerly winds over the northern North Atlantic (Rogers, 1984). Strong NW winds, cold temperatures and heavy ice in the Labrador Sea area are associated with a strong positive NAO index (Colbourne et al. 1994; Drinkwater 1994). The annual NAO index is derived from the measured mean sea level pressures at Ponta Delgada in the Azores minus those at Akureyri in Iceland (Fig. 6). The small number of missing data early in the time series was filled using pressures from nearby stations. The NAO anomalies were calculated by subtracting the 1961-90 mean. In 1995, the NAO anomaly was strongly positive and above last years's value, continuing the trend of above average NAO anomalies since the late 1980s. Over the past 30 years there has been large decadal variability superimposed upon a general upward trend from a minima in the mid-1960s. Note that the timing of the three most recent peaks in the NAO index corresponds to the periods of cold air temperature anomalies in the Labrador Sea (Fig. 4). Given the positve relationship between air temperatures and the NAO index and high value of the latter in 1995, air temperatures in the Labrador Sea region were expected to be colder than in recent years. However, because the Icelandic Low shifted eastward, this resulted in less influence of the Low over the Labrador Sea than might be expected during a normal high NAO index year.

SEA ICE OBSERVATIONS

Newfoundland and Labrador

Information on the location and concentration of sea ice is available from the daily ice charts published by Ice Central of Environment Canada in Ottawa. The long-term medians, maximum and minimum positions of the ice edge (concentrations above 10%) based on the composite for the years 1962 to 1987 are taken from Coté (1989).

At the end of December 1994, ice had spread south to the Strait of Belle Isle and the ice edge was near its long-term median position (Fig. 7). During the first two weeks of January, very cold air temperatures promoted ice formation and strong northwesterly winds also pushed the ice rapidly southward. This lead to the ice edge laying between the long-term median and maximum positions by 15 January. The southward advance continued through the rest of the month at a normal rate so that by 1 February the ice edge still maintained its position between the median and maximum locations. The offshore boundary off Labrador was near normal, however. Cold, windy conditions in February resulted in the ice edge reaching the Avalon Peninsula by the middle of the month, almost two weeks ahead of schedule. By 1 March, the southward movement slowed but westerly winds pushed the ice offshore of northern Newfoundland to near its long-term maximum location. At the beginning of April, ice along the Newfoundland coast was at its maximum southward extent. Northeasterly winds during the last 2 weeks of March pushed the ice shoreward. Warm temperatures in April lead to extensive ice decay along the eastern and southern edges while east to northeasterly winds kept the ice inshore, compacting it further into the coastal regions. Increasing temperatures lead to further decay of the ice and the northward retreat of the ice edge. Westerly winds in May pushed all of the ice from Conception and Bonavista Bays and by the end of the month it had disappeared entirely. Ice remained offshore of White Bay and Notre Dame Bay and along the coast of Labrador, however. June saw the continual retreat of the ice edge and by 1 July all of the sea ice had disappeared from Newfoundland and southern Labrador waters.

The Ice Climatology and Applications Division of Environment Canada undertook an analysis of ice conditions off the east coast of Newfoundland and southern Labrador and in the Gulf of St. Lawrence by determining the time of onset, duration and last presence of ice at 24 grid sites (Fig. 8). For each site, the extracted data include ice duration in weeks, as well as minimum, maximum and mean duration for years when ice was present (Table 1). For the 1994/1995 ice season, we continued the analysis. Ice first appeared off southern Labrador in mid-December of 1994, approximately 1 week earlier than normal (Fig. 9, negative anomaly). On the Newfoundland shelf and the Grand Banks, the ice generally appeared earlier-than-normal by 1-2 weeks except nearshore, off St. John's, and far offshore at N66 where it arrived within a few days of its normal date. Ice was not observed during the season at the far offshore sites N25, N27, N68, N70, N112, and N114. Ice has never been observed at sites N27 and N70, and in 36 years of observations has only reached N25 and N114 in 2 and 5 years, respectively, and in less than half the years at N68 and N112. In 1995, at the furthest offshore sites where ice was observed, ice left early by upwards of 3 weeks (Fig. 10), due primarily to strong easterly winds pushing the ice inshore. On the rest of the shelf, the ice lasted longer than normal, over 4 weeks off St. John's. This resulted in the duration being longer-than-normal off southern Newfoundland and inshore Labrador but it was shorter-than-normal further offshore and off northern Newfoundland (Fig. 11). Note that the duration is not simply the date of the first presence minus the last presence because the ice can disappear and then reappear.

The monthly time series of the areal extent of ice on the northern Newfoundland and southern Labrador shelves (between 45-55°N) from the 1960s to present are shown in Fig. 12. In January through April there has been a general increase in the area of ice over the past 30 y.

The ice coverage from January to April 1995 was generally above average but declined relative to 1994. These data support 1995 being a heavier-than-average ice year on the Labrador and Newfoundland shelves but not as severe as the last three or four years.

Icebergs

The number of icebergs that pass south of 48°N latitude in each year is monitored by the International Ice Patrol Division of the United States Coast Guard. Since 1983, data have been collected with SLAR (Side-Looking Airborne Radar). During the 1994/95 iceberg season (October to September), a total of 1432 icebergs were spotted south of 48°N. The monthly totals for February to August were 43, 385, 334, 405, 218, 41, and 6 (Fig. 13). No icebergs were spotted between October, 1994, and January, 1995, inclusive, or in September, 1995. In the primary iceberg season of March to July, 1383 icebergs were observed which represents 97% of the annual total and is higher than the 1983-1994 average of 89%. The percentage of the total number of icebergs by month for the 1994/95 season shows that proportionally more penetrated south of 48°N in March and May then normal and fewer after May. Although the total number of icebergs in 1995 was relatively high, it was down by approximately 200 from last year. The time series of iceberg counts during March to July beginning in 1945 when aerial reconnaissance was first established shows that in the 1990s the number of icebergs has been much higher than normal (Fig. 13). Other periods of large number of icebergs reaching south of 48°N occurred in the mid-1980s, and the early 1970s, all periods of cold air temperatures, strong NW winds and extensive ice cover.

Gulf of St. Lawrence

Relatively warm temperatures in the western Gulf of St. Lawrence during December 1994 resulted in less ice formation than normal on the Magdalen Shallows, however, colder-than-normal temperatures in the Esquiman Channel area produced more ice than usual along the north shore of Quebec (Fig. 14). In early January air temperatures dropped below normal throughout the Gulf. This advanced freeze-up, although by mid-month the ice coverage on the Magdalen Shallows was still less than usual. Along the north shore of the Gulf and ice conditions remained slightly ahead of normal. During the latter half of January, temperatures rose above normal slowing the spread of ice but extremely cold temperatures and northwesterly winds during the first two weeks of February quickened the southward advance and pushed the ice out through Cabot Strait. By late February the Gulf was ice covered except for a small area off SW Newfoundland. Ice extended onto the northeastern Scotian Shelf and lay near its normal position by 1 March. Cold temperatures in early March produced heavier than normal ice conditions. Later in the month, rising temperatures and northeasterly winds caused large areas of open water to develop off western Newfoundland, off Anitcosti Island and along the Quebec north shore. The winds also packed ice into the southern Estuary, Chaleur Bay and eastern Cape Breton and pushed it southwestward along the Atlantic coast of Nova Scotia to Canso. Near normal temperatures and light to moderate northeasterly winds during April cleared much of ice from the Gulf. By the beginning of May only isolated patches of ice persisted in the Gulf. By 8 May ice disappeared from the Magdalen Shallows and a week later from around southern Cape Breton.

The last ice to leave the Gulf was in the vicinity of Belle Isle Strait and it was gone by the first week in June.

Ice in the Gulf of St. Lawrence generally appeared within a week of its usual arrival date or was later-than-normal (up to 2 weeks; Fig. 9). Exceptions were in the Estuary and off eastern Cape Breton where the ice arrived over a week early. No ice was observed off southern Newfoundland at grid point G35. Throughout the Gulf and on the Scotian Shelf the ice stayed around longer-than-normal by upwards of 5 weeks on the northern Magdalen Shallows (Fig. 10) with a new record established for the latest date of the last presence of ice off Baie des Chaleurs (site G22; Fig. 10). The ice duration (Fig. 11) was longer-than-normal (by 2-4 weeks) throughout most of the northern Gulf but less-than-normal in the southern Magdalen Shallows and in the Cabot Strait region. A record for ice duration was set on the northern Magdalen Shallows (17 weeks at G22) and equalled in the northeastern Gulf (17 weeks at G10).

Recently we digitized the location of the ice edge in the Cabot Strait and Scotian Shelf regions from the 1-3 weekly ice charts for the years 1970 to present. These data were combined to produce monthly estimates of the average ice area seaward of Cabot Strait (Fig. 15). The ice area time series are dominated by variability at 3-5 y periods. The areal extent in 1995 was down significantly from last year. It arrived late but lasted longer-than-normal, at least in the inshore areas around Cape Breton Island. The late ice was not evident at the grid points in Fig. 10. In terms of the total amount of ice that reached the Scotian Shelf it was a generally an average year although the ice was present for a longer time then usual.

OUTLOOK FOR 1996

The air temperatures in January 1996 along the Labrador coast and over the Gulf of St. Lawrence and the Scotian Shelf were below normal during the first half of the month and above normal to near normal in the second half. Ice in all areas was near normal during January. A similar pattern of air temperatures occurred in February, i.e. cold at the beginning of the month but warming later in the month. Many storms traversed the region producing fluctuating temperatures and the associated strong winds helped to break up the ice. By mid-February, the ice was near normal in the Gulf while off Newfoundland it was not as far south as normal but was near its long-term maximum position at its offshore leading edge. Based upon the previously observed decadal variability and the warming trend of the last 2 year, it might be expected that the atmospheric conditions in Labrador and Newfoundland during winter may continue to moderate. This will continue to produce warmer air temperatures, weaker winds and less ice than were experienced in the early years of the 1990s.

SUMMARY

During 1995, wintertime air temperatures over eastern Canada were generally colder-than-normal. This is consistent with the high positive value of the NAO index caused by the intensification of the Icelandic Low and Azores High. This intensification resulted in stronger NW winds over the region which brought cold Arctic air further south. The cold conditions and stronger NW winds resulted in earlier ice formation, greater areal extent of ice than normal and a longer duration of ice, over much of the Labrador/Newfoundland shelves and in the Gulf of St. Lawrence/Scotian Shelf. The cold temperatures, strong winds and extensive ice all contributed towards a large number of icebergs reaching the Grand Banks. Winter conditions were, however, not as severe as last year or the early 1990s although the NAO index in 1995 was the highest since 1990. A higher NAO index, generally results in colder air temperatures and more ice. While the Icelandic Low and the Azores High intensified, resulting in the high NAO index, they also shifted east to northeastward, which reduced their influence in the Labrador Sea. This is believed to be the reason that although the NAO index increased relative to the other years in the 1990s, the winter conditions in the Labrador Sea were not as severe.

During the spring to autumn, air temperature anomalies were above normal. The maximum warming occurred in the north during the autumn and is related to strong southwesterly to southerly winds caused by an anomalous high pressure system that developed over Greenland. These warm conditions resulted in annual air temperatures that were generally near or above their long-term means and represented significant warming compared to recent years. The warmest site was Iqaluit on Baffin Island where the annual anomaly was 1.6°C above normal.

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TABLE 1. Historical data on presence and duration of sea ice at 24 sites off eastern Canada and ice duration at these sites in the 1994/95 (October-September) ice year with 1993/94 data in parentheses.

				Ice Duration (in weeks)				
				When ice present				
Site	Seasons Studied	# of Yrs	Yrs ice	Min	Max	Mean	Overall Mean	94/95 (93/94)
G-7	67/68-94/95	28	28	6	16	10.8	10.8	14 (14)
G-10	76/77-94/95	19	19	3	17	12.4	12.4	17 (15)
G-12	67/68-94/95	28	28	2	15	11.7	11.7	13 (12)
G-22	76/77-94/95	19	19	7	17	12.3	12.3	17 (15)
G-31	68/69-94/95	27	26	8	17	12.6	12.1	12 (13)
G-33	71/72-94/95	24	24	2	14	10.8	10.8	10 (13)
G-35	59/60-94/95	36	19	1	11	3.5	1.8	0 (4)
G-86	76/77-94/95	19	19	6	23	16.7	16.7	18 (20)
G-87	70/71-94/95	25	24	1	12	7.6	7.3	7 (8)
N-19	66/67-94/95	29	29	17	32	23.9	23.9	25 (25)
N-21	67/68-94/95	28	28	5	28	18.6	18.6	18 (23)
N-23	59/60-94/95	36	30	1	17	5.1	4.2	1 (5)
N-25	59/60-94/95	36	2	1	1	1.0	0.1	0 (0)
N-27	59/60-94/95	36	0	0	0	0.0	0.0	0 (0)
N-62	67/68-94/95	28	28	8	27	18.7	18.7	16 (20)
N-64	59/60-94/95	36	35	3	25	13.2	12.8	13 (18)
N-66	59/60-94/95	36	30	1	17	8.6	7.1	5 (16)
N-68	59/60-94/95	36	16	1	10	3.5	1.6	0 (3)
N-70	60/61-94/95	35	0	0	0	0.0	0.0	0 (0)
N-108	59/60-94/95	36	30	1	17	6.3	5.3	10 (6)
N-110	59/60-94/95	36	29	1	16	5.6	4.6	7 (10)
N-112	59/60-94/95	36	15	1	10	4.1	1.7	0 (7)
N-114	59/60-94/95	36	5	1	2	1.6	0.2	0 (2)
N-228	59/60-94/95	36	25	1	14	5.9	4.1	10 (4)

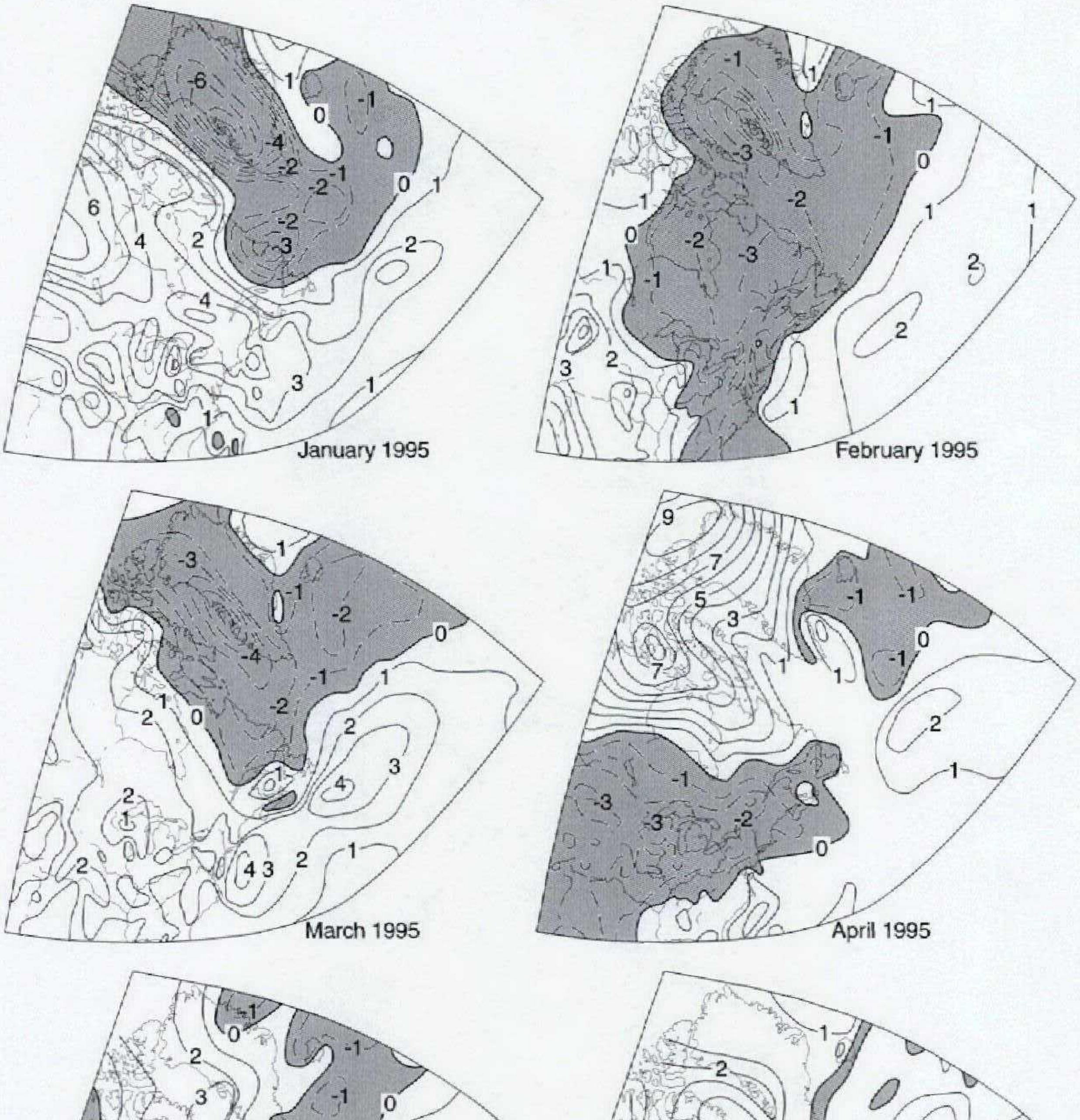


Fig. 1. Monthly air temperature anomalies (^{o}C) over the NW Atlantic and eastern Canada in 1995 relative to the 1961-90 means. Shaded areas are negative anomalies. (From *Grosswetterlagen Europas*)

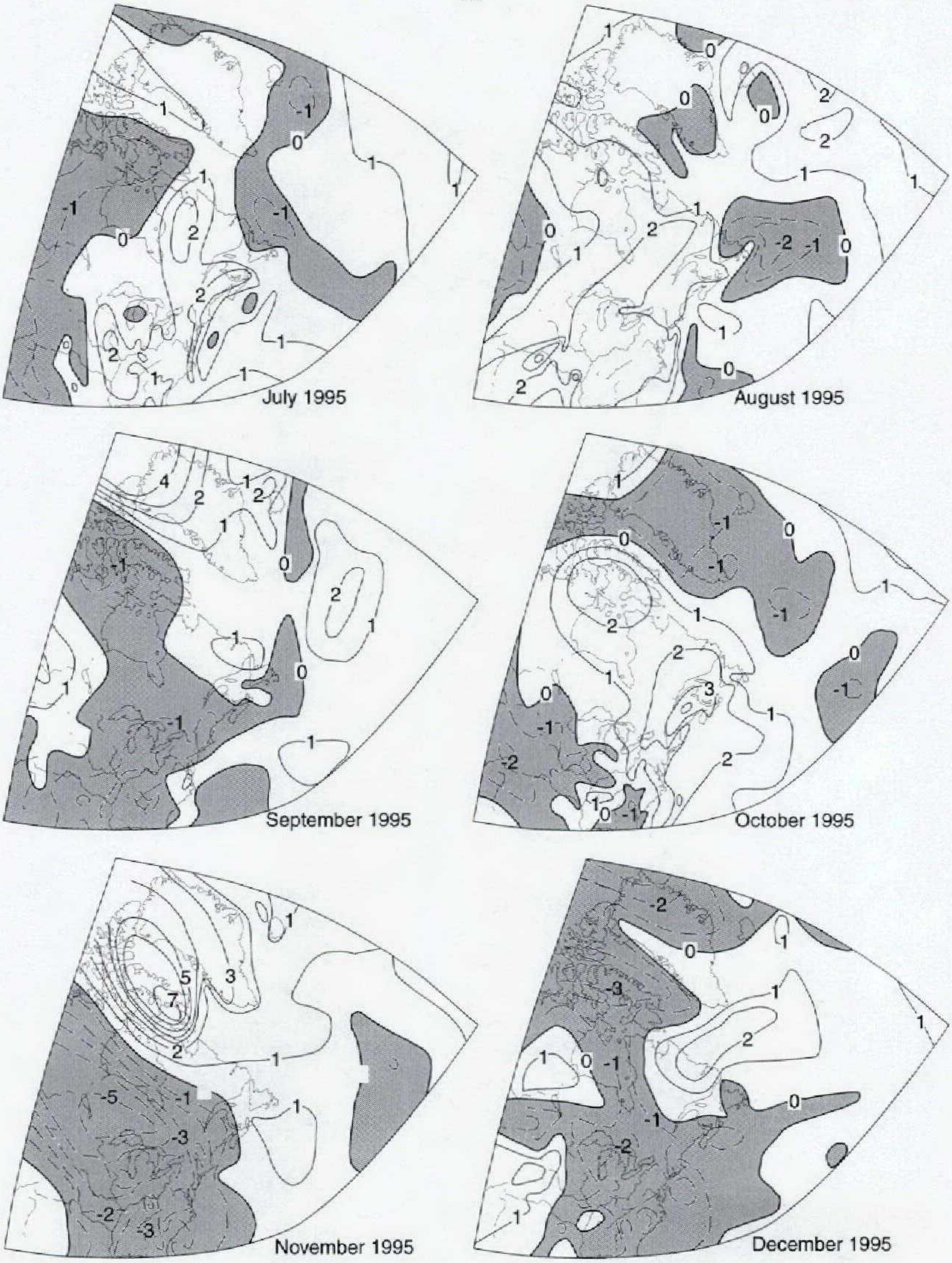


Fig. 1. (continued). Monthly air temperature anomalies (^{o}C) over the NW Atlantic and eastern Canada in 1995 relative to the 1961-90 means. Shaded areas are negative anomalies. (From *Grosswetterlagen Europas*)

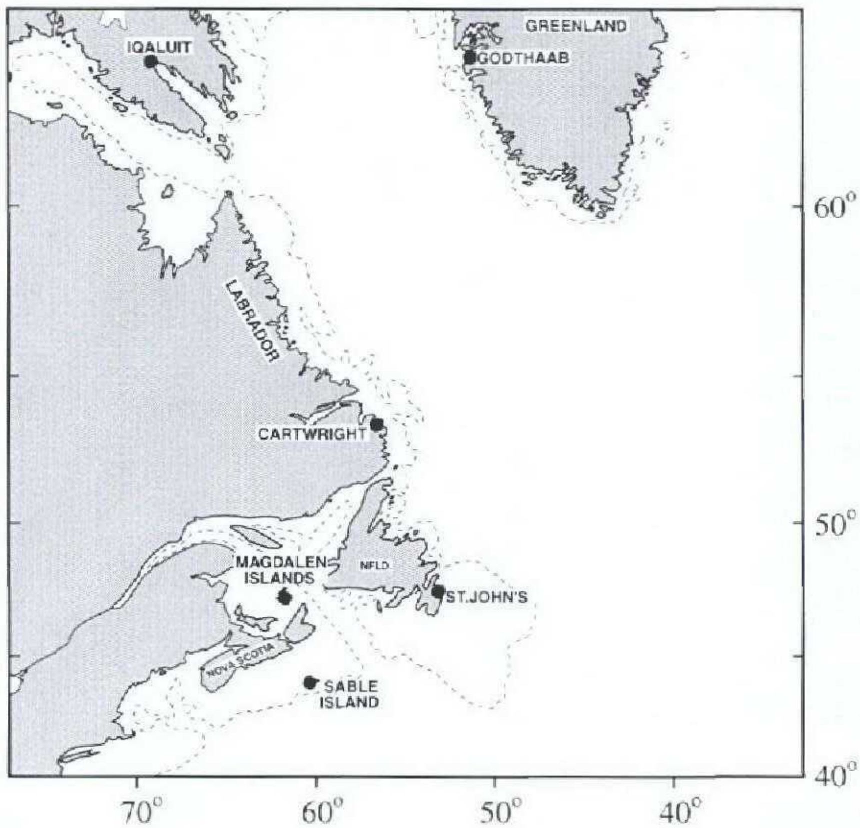


Fig. 2. Eastern Canada and Greenland showing coastal air temperature stations.

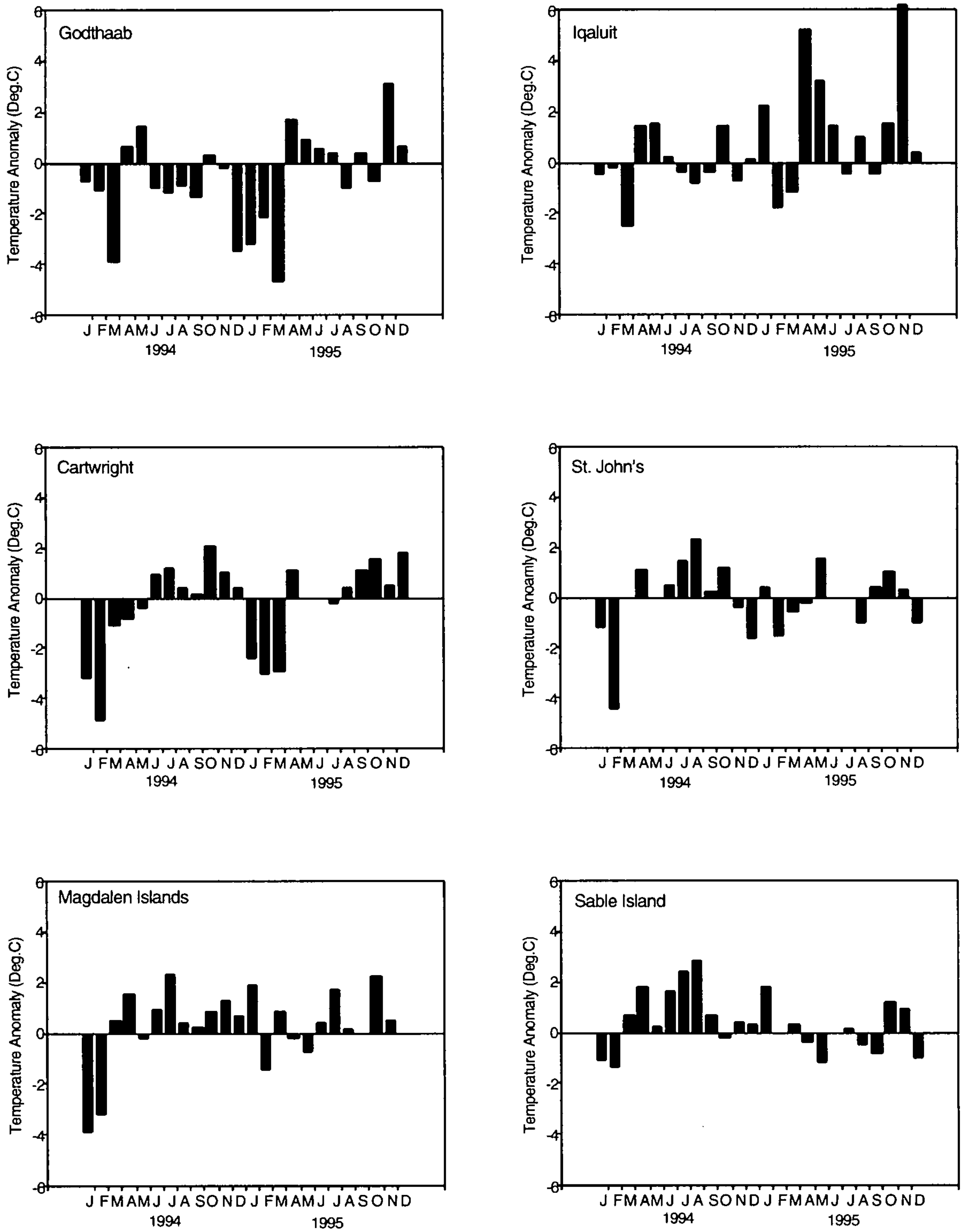


Fig. 3. Monthly air temperature anomalies in 1994 and 1995 at selected coastal sites (see Fig. 2 for locations).

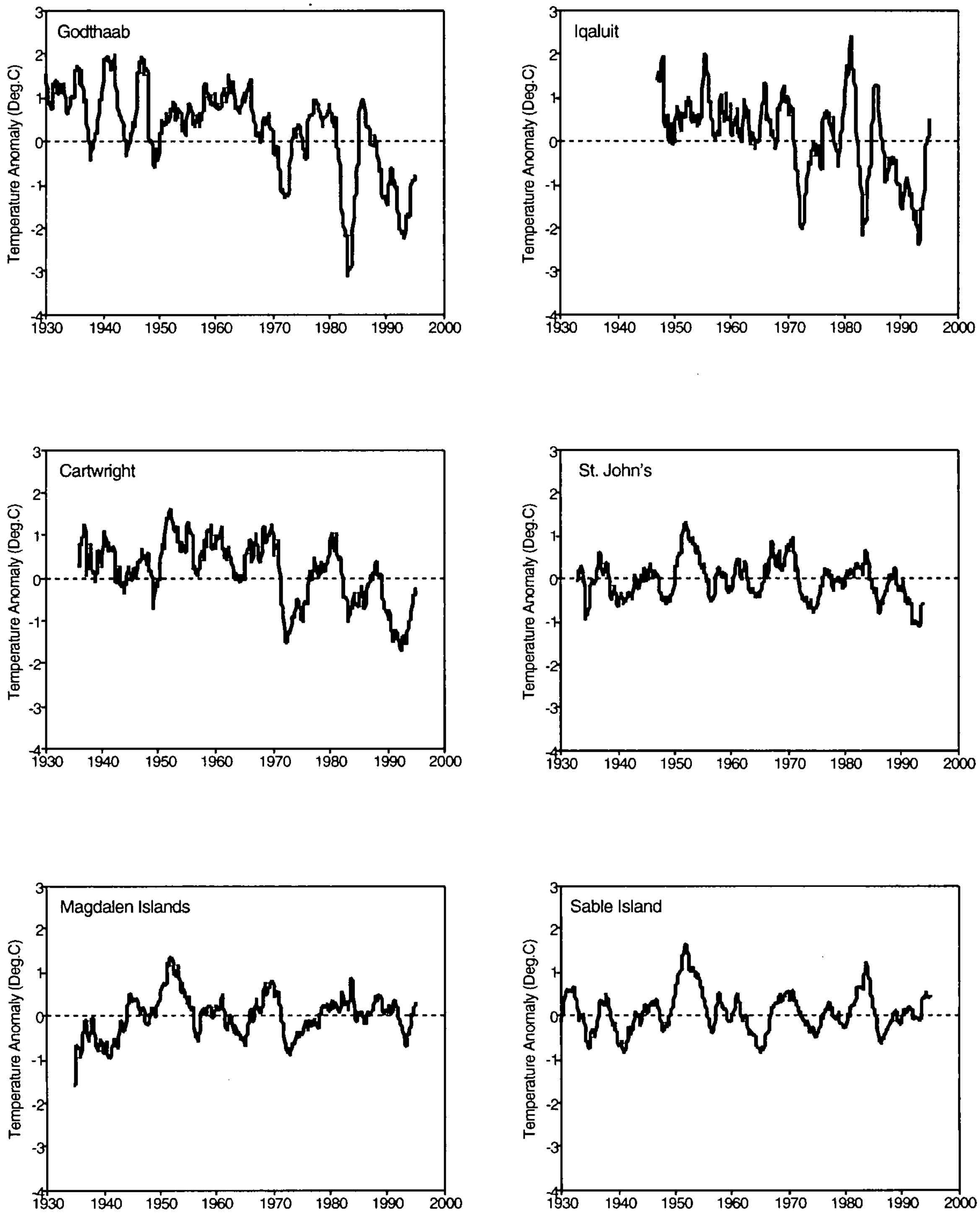


Fig. 4. Twenty-five month running means of monthly air temperature anomalies at selected sites.

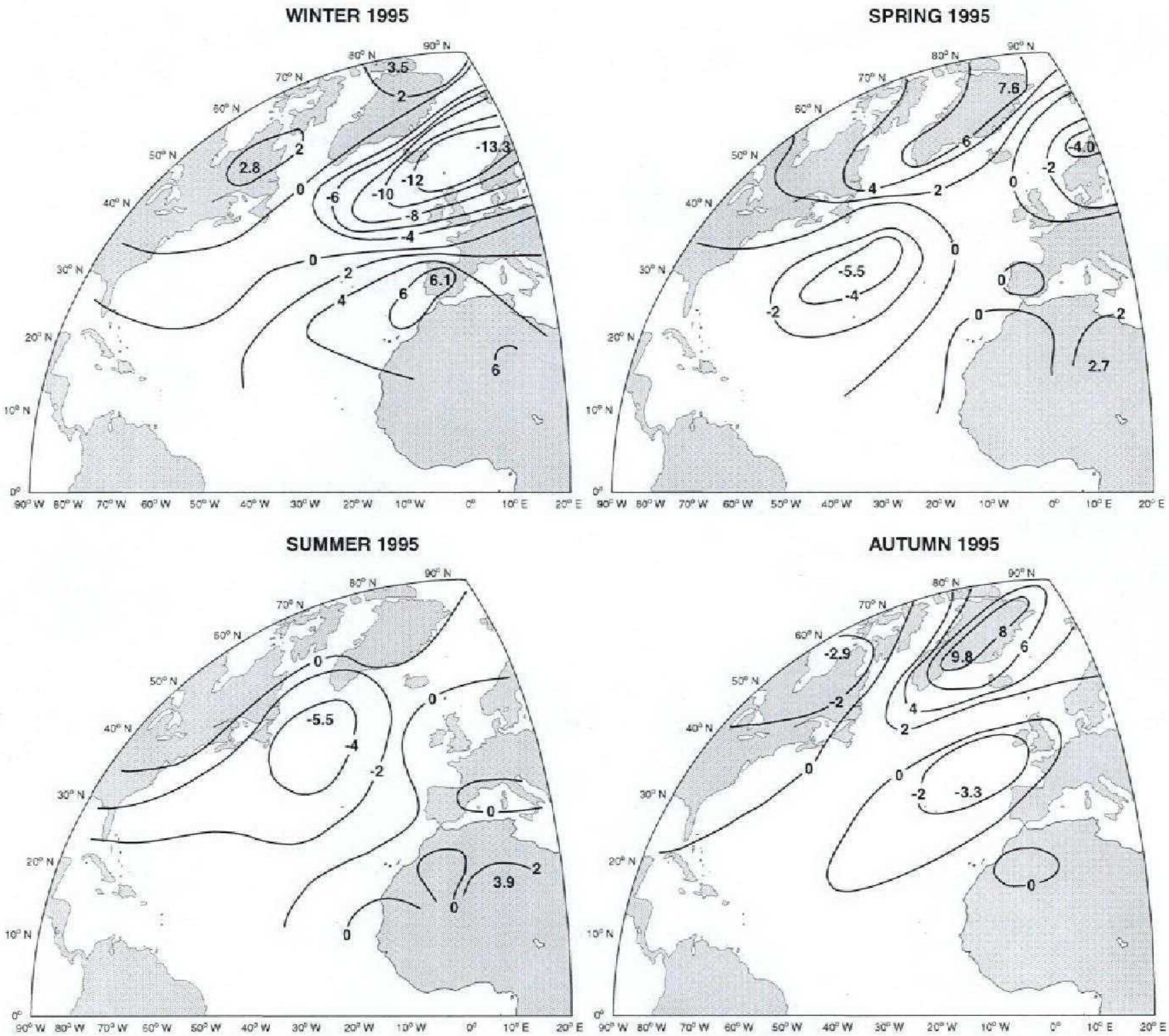


Fig. 5. Seasonal sea-surface air pressure anomalies (mb) over the North Atlantic in 1995 relative to the 1961-90 means.

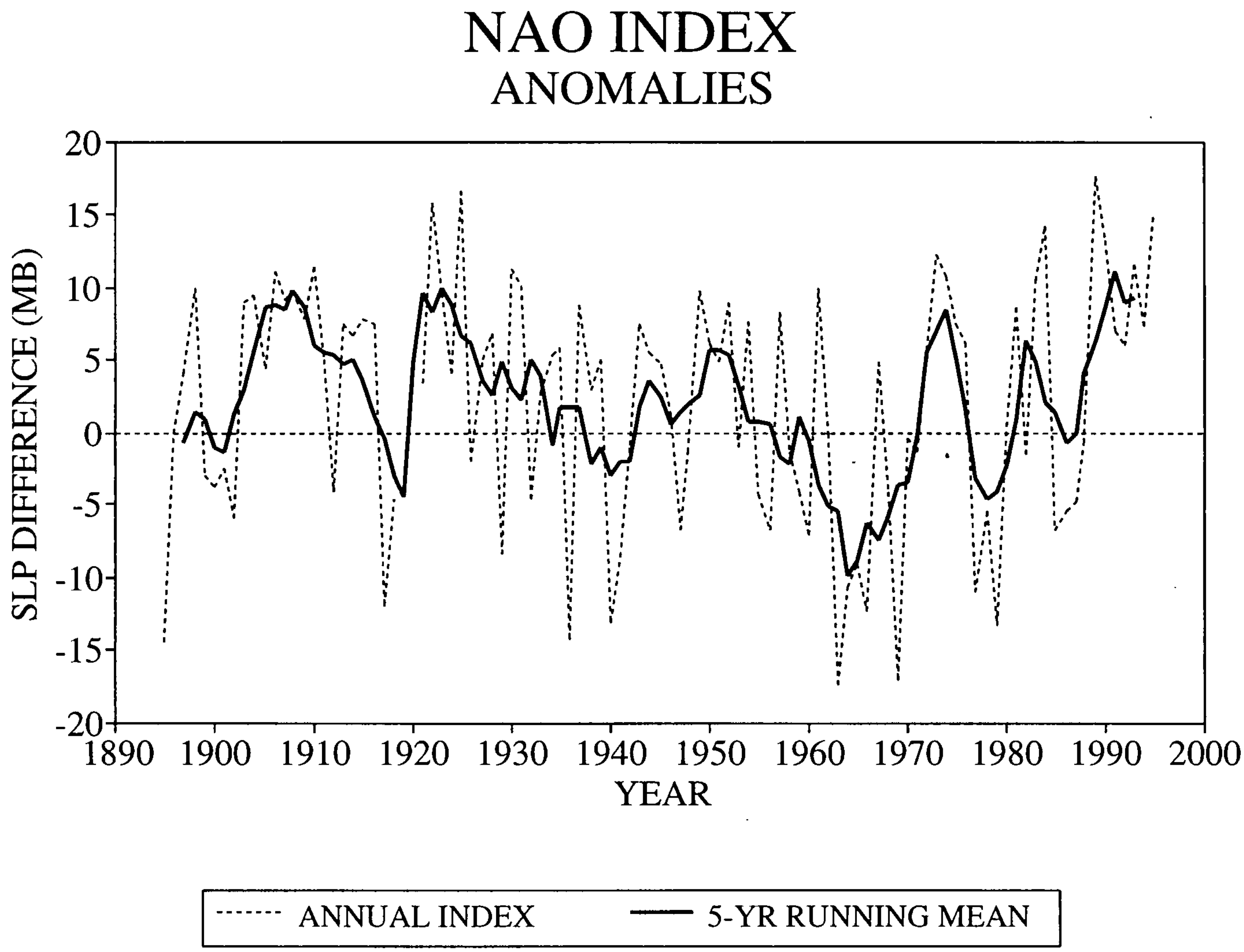


Fig. 6. Anomalies of the North Atlantic Oscillation Index, defined as the winter (December, January, February) sea level pressure at Ponta Delgada in the Azores minus Akureyri in Iceland, relative to the 1961-90 mean.

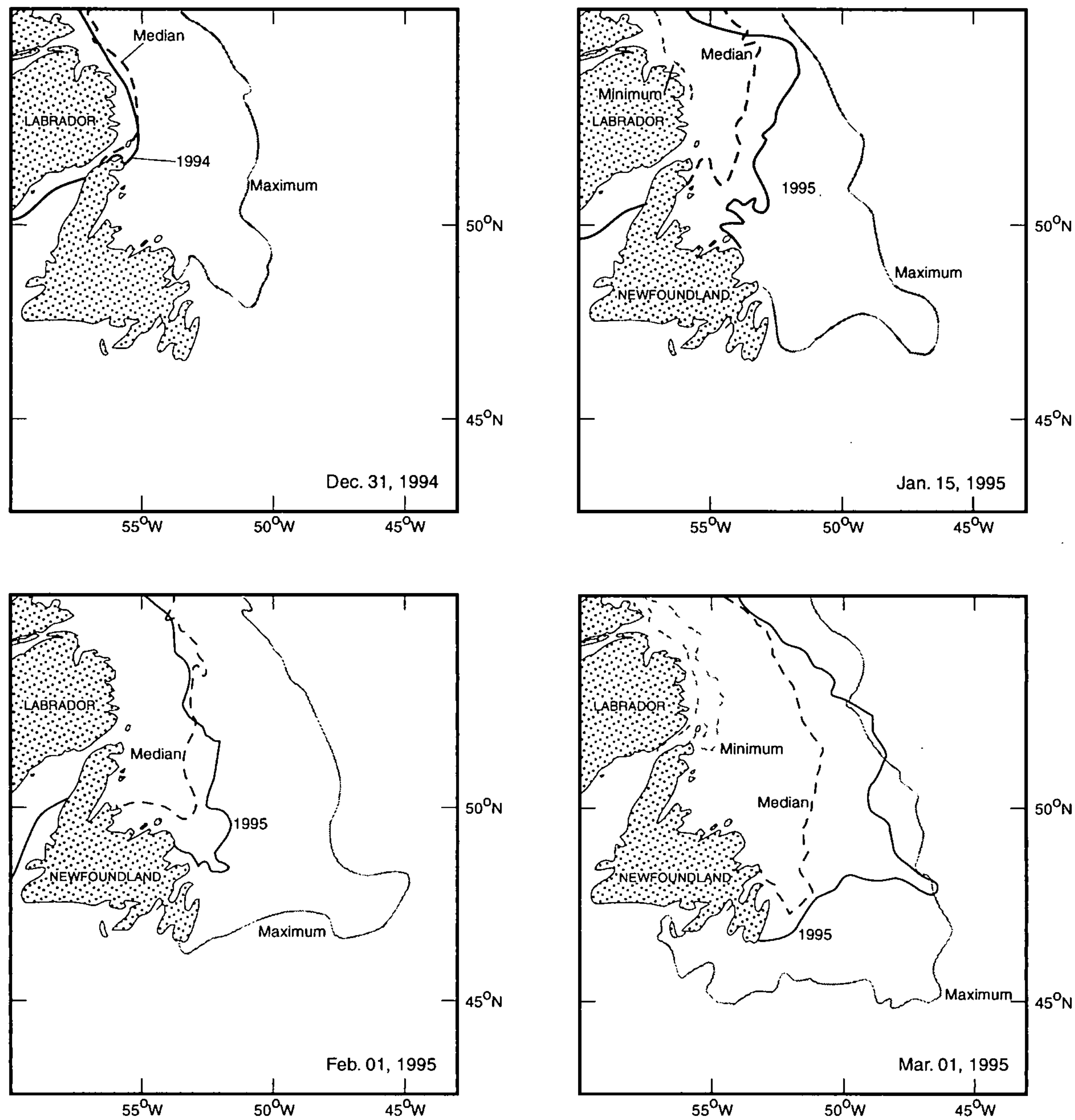


Fig. 7a. The location of the ice edge together with the historical (1962-1987) median and maximum positions off Newfoundland and Labrador between December 1994 and March 1995.

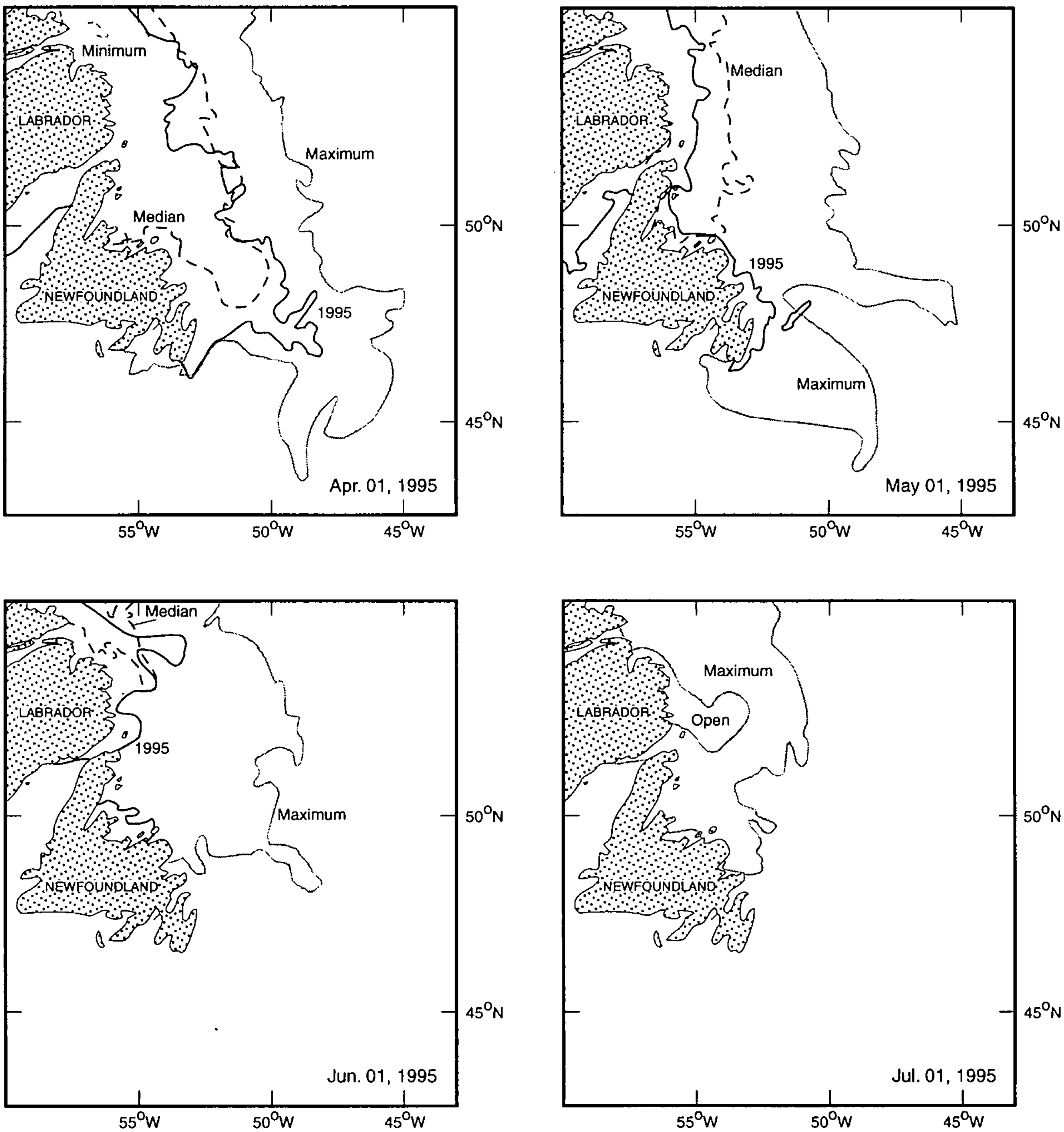


Fig. 7b. The location of the ice edge together with the historical (1962-1987) median and maximum positions off Newfoundland and Labrador between April and July 1995.

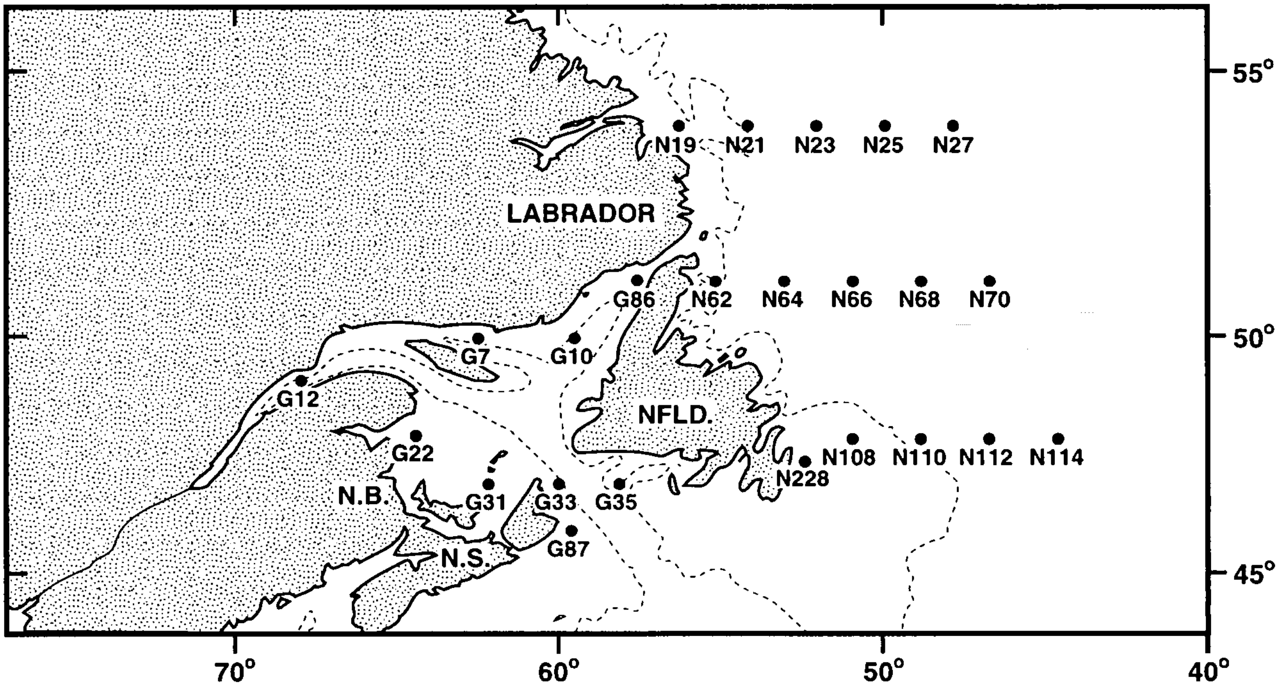


Fig. 8. Location of 24 grid points in the Northwest Atlantic where ice statistics have been extracted from ice charts.

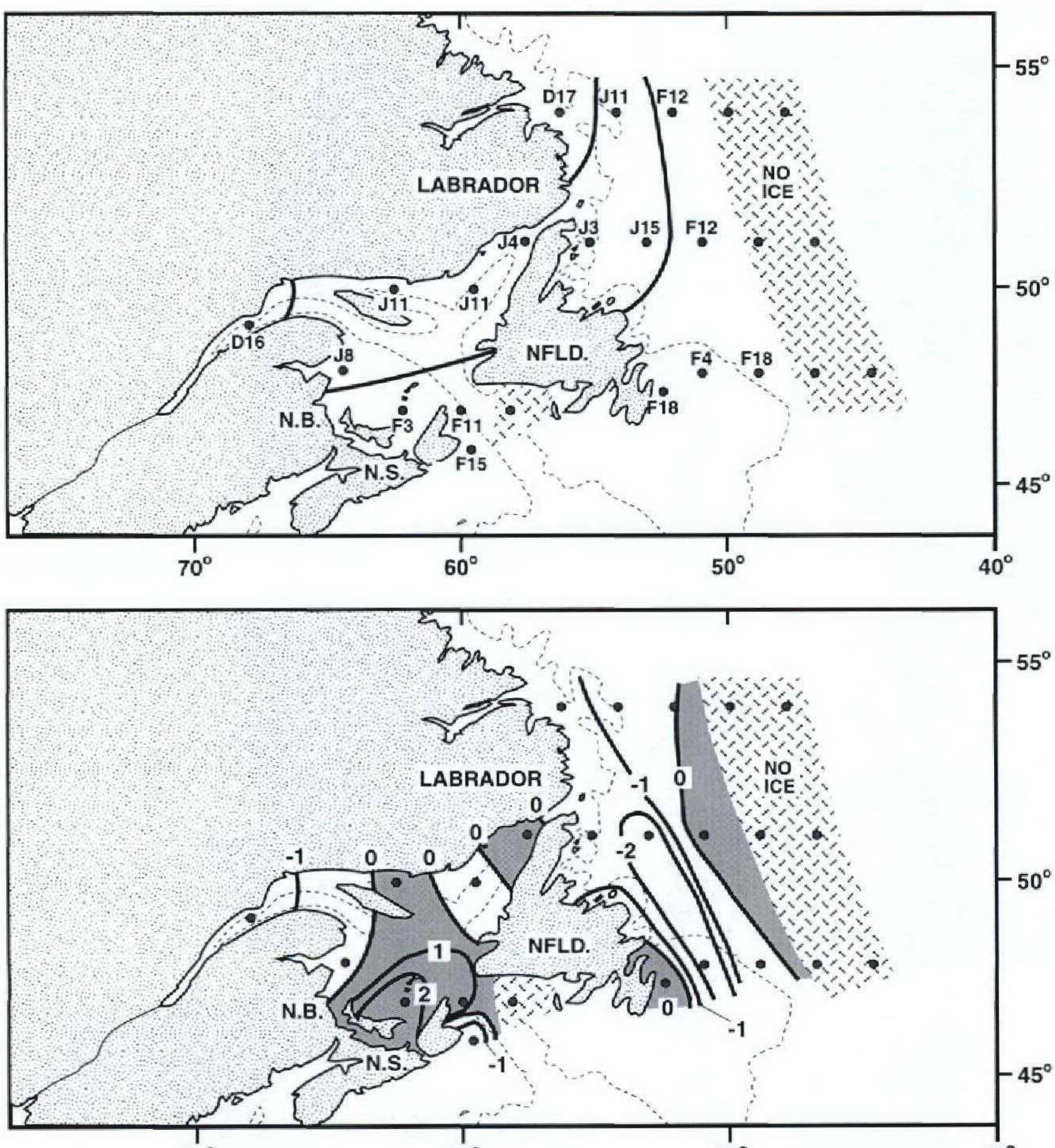


Fig. 9. The date at which ice first appears at the grid points in Fig. 8 (top) and their anomalies, in weeks, from the long term mean (bottom). A negative anomaly indicates ice appeared earlier than normal.

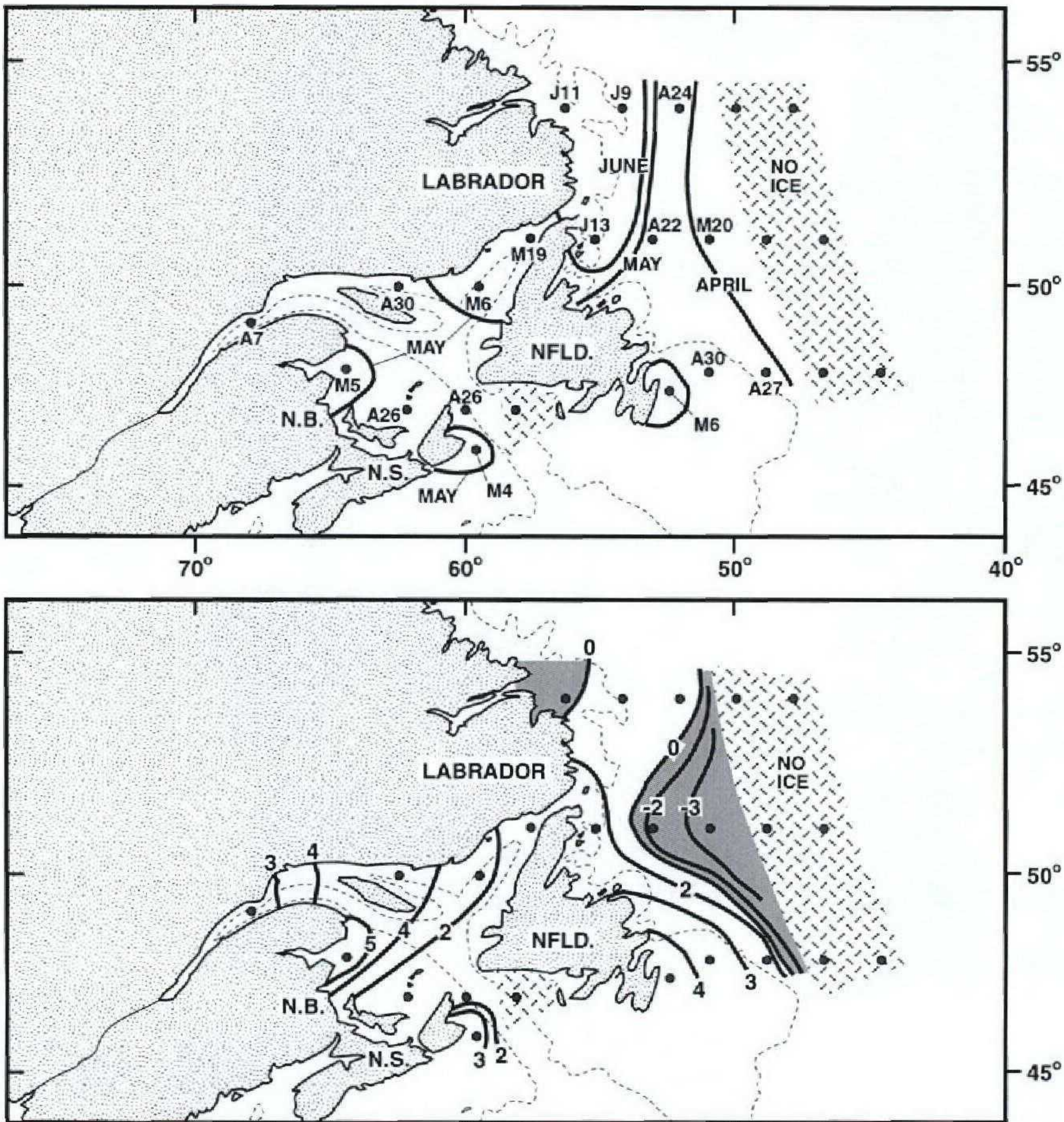


Fig. 10. The date at which ice last appears at the grid points in Fig. 8 (top) and their anomalies, in weeks, from the long term mean (bottom). A positive anomaly indicates ice lasted longer than normal.

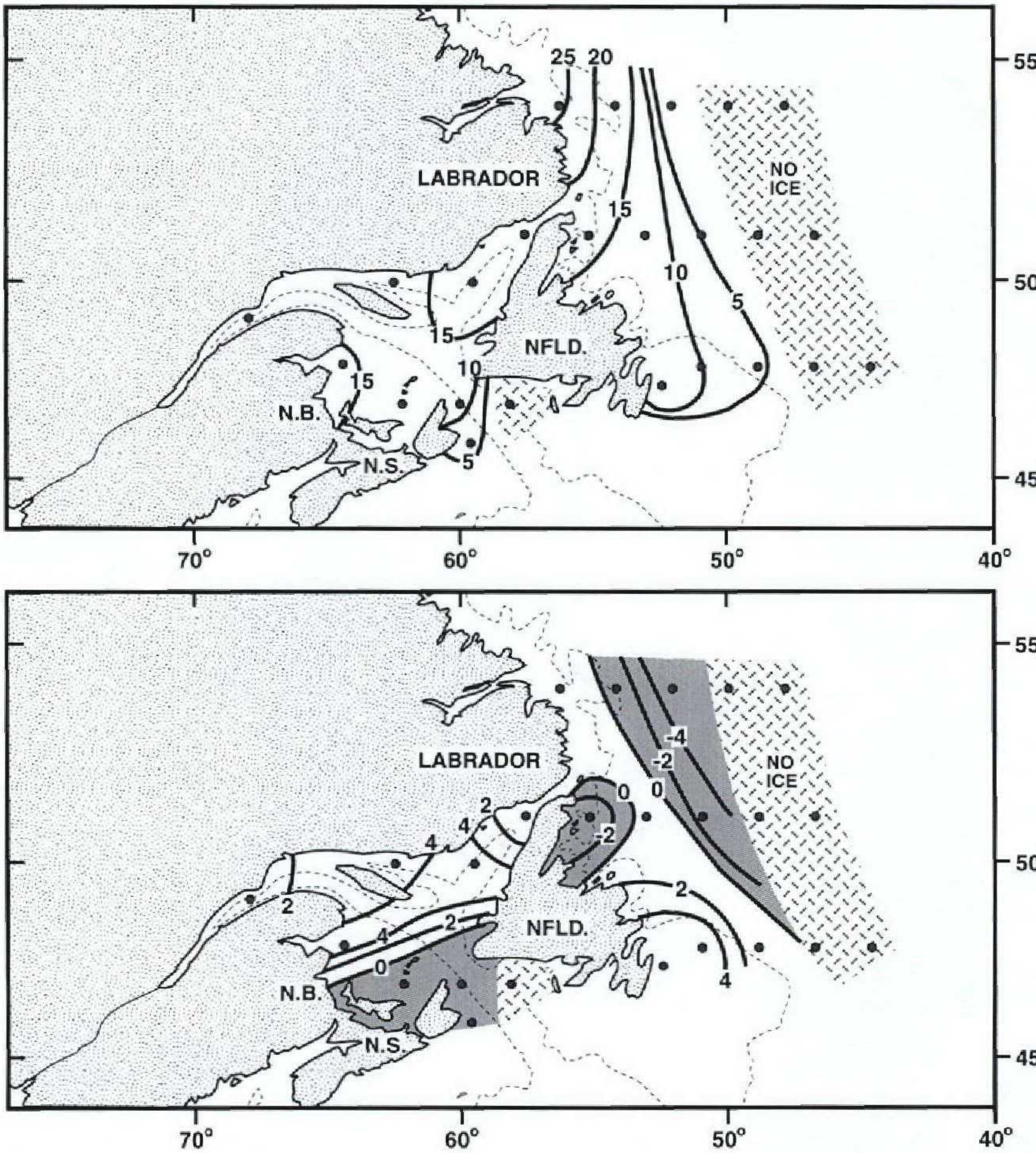


Fig. 11. The duration of ice (top) and its anomaly, in weeks, relative to the long-term mean (bottom). Positive anomalies indicate a duration longer than the mean.

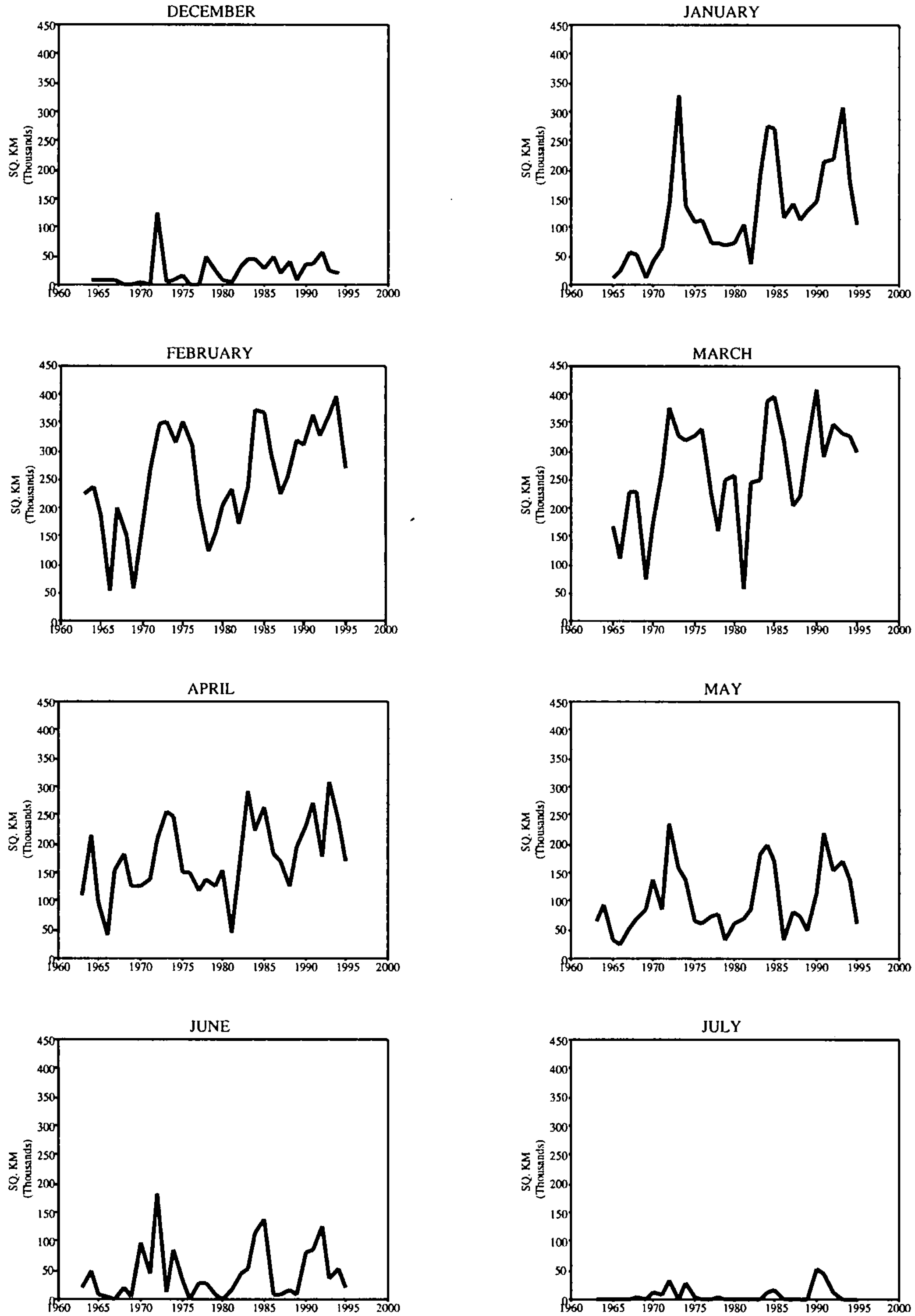
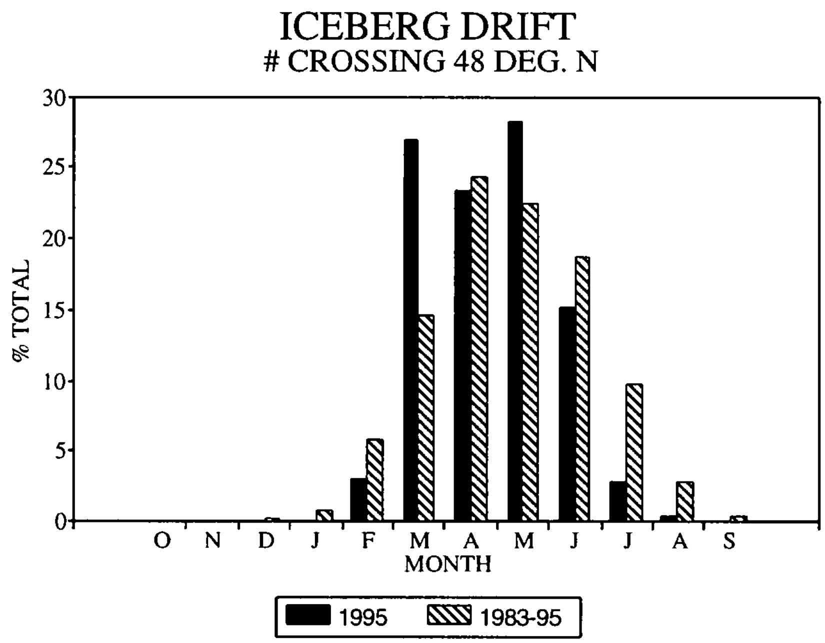


Fig. 12. The time series of ice area on the southern Labrador and northern Newfoundland shelves between 45°N-55°N by month.



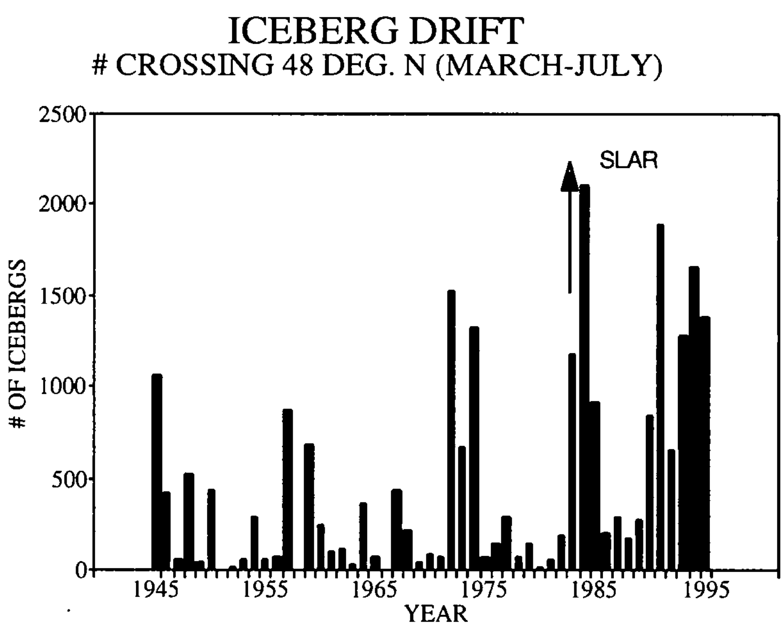


Fig. 13. The percentage of the total number of icebergs crossing south of 48°N by month during the iceberg season 1994/95 (top) and the number of icebergs during March to July from 1945 to 1995. The vertical arrow indicates the year they began to detect icebergs using SLAR.

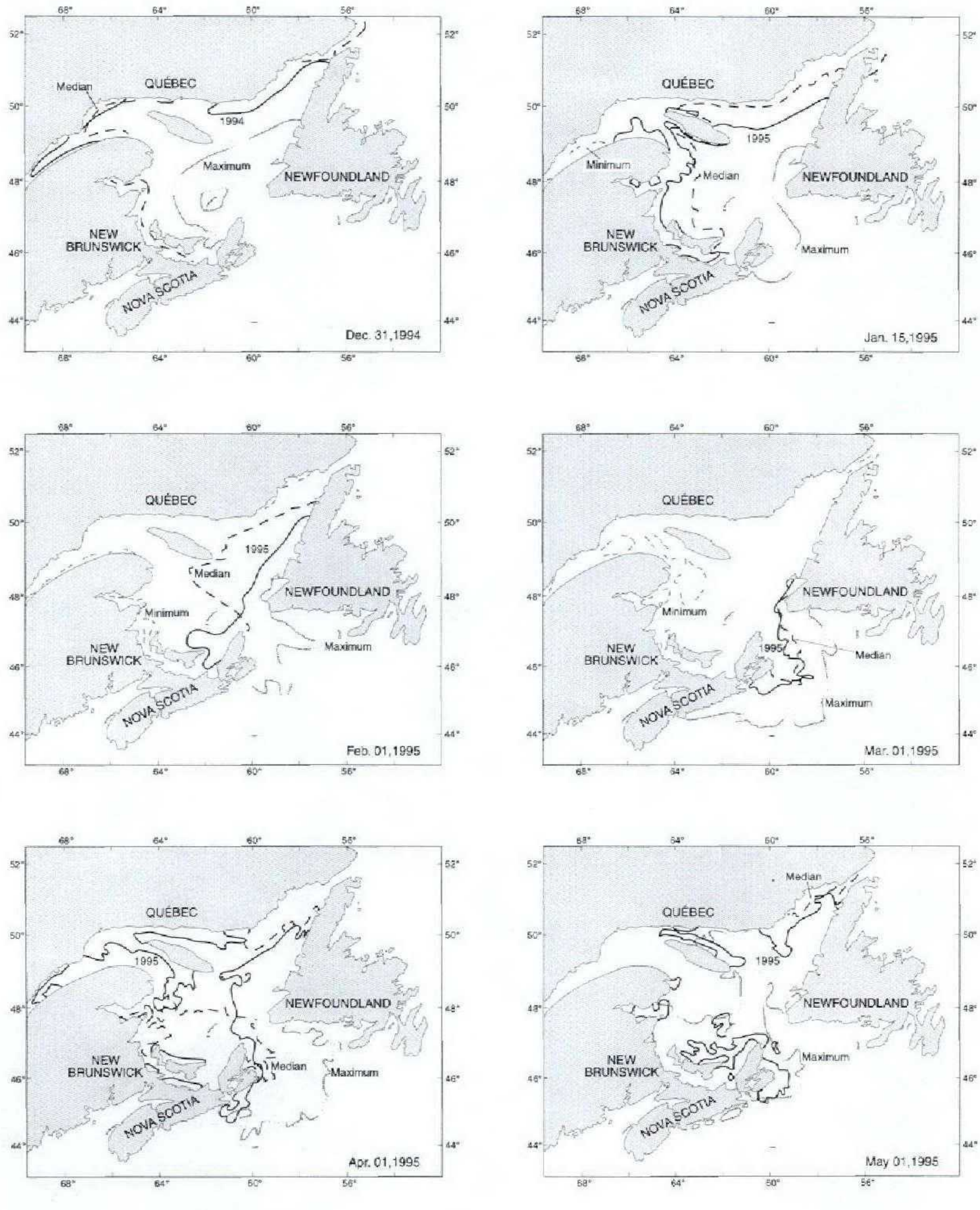


Fig. 14. The location of the ice edge together with the historical (1962-1987) median and maximum positions in the Gulf of St. Lawrence between December 1994 and May 1995.

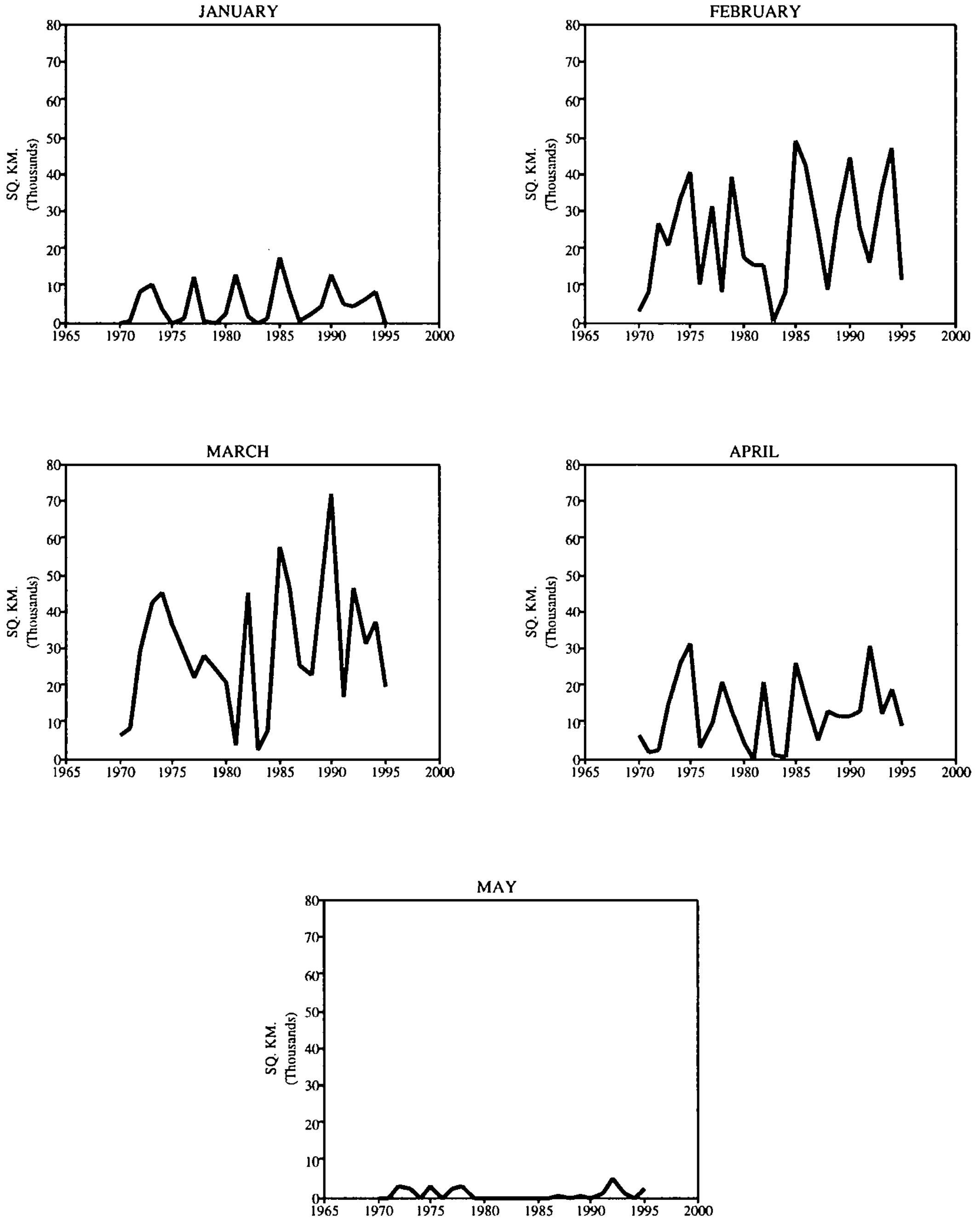


Fig. 15. The time series of ice area seaward of Cabot Strait by month.