Short-Term Variations of Polar-Ice

Selected examples off south and southeast Greenland

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Abstract

The paper illustrates the advantage of air observation of the ice, and some examples from the year 1961 are given concerning the influence of the wind upon the ice drift.

Introduction

The ice in the Greenland waters has currently been dealt with since 1892 in yearbooks published by the *Danish Meteorological Institute*. Various other papers have been issued on the subject, but with a few exceptions they were until recently solely descriptive, as the information they were based upon was rather scattered and inhomogeneous. In fact, the only existing knowledge originated from land-observations and from ships with only a few observations from the air.

The observation height from a ship is low and the observed area consequently small. Approaching an ice area the observer will mostly not be able to state whether he is facing the continuous belt of polar ice or just a detached belt or string. Further, he might easily exaggerate the concentrations of the ice. Consequently, the observations from ships will often be more pessimistic than observations from an aircraft. Moreover, the navigator will try to avoid the ice, why exact observations of the concentrations, age etc. of the ice cannot be made. Nevertheless, we still use the observations of ships from various countries to a great extent as a supplement when flying has not been effected or when dense clouds are obstacling the possibilities of visual observations from the air.

Soon after World War II American air ice-reconnaissances at Greenland commenced (1952), and by courtesy of US Navy Hydrographic Office (now: *US Naval Oceanographic Office*) we got much more detailed information about the ice-conditions.

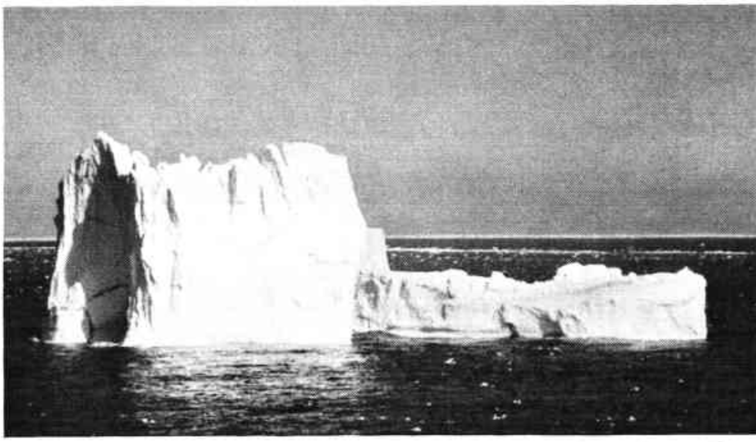


Fig. 1. Iceberg SE of Scoresby Sund. It projected more than 120 m above sea level and probably it had a draught of 3—400 m. Normally, the icebergs at Greenland do not project more than 50 m, but 170 m have been observed. The icebergs are also influenced by the deeper currents, and will often move at another rate and path than the sea ice. This iceberg was photographed (May 19, 1962) abt. 15 nm outside the polar ice belt. It is not yet elucidated whether some of the icebergs from the East Greenland Current may join the Labrador Current and thus go into the North Atlantic shipping routes.

Fig. 1. Isfjeld SØ for Scoresby Sund. Fjeldet når 120 m over havoverfladen og har antagelig et dybgående på 3—400 m. Normalt når isfjeldene ved Grønland kun en højde af 50 m, dog er indtil 170 m observeret. Da isfjeldene også påvirkes af dybereliggende strømme, bevæger de sig ofte med en anden hastighed og ad en anden bane end havisen. Det afbildede isfjeld blev således fotograferet (19. maj 1962) ca. 15 sømil uden for storisbæltet. Det er endnu ikke klarlagt, hvorvidt enkelte af isfjeldene fra Østgrønland når ind i Labradorstrømmen og føres med ned i de nordatlantiske sejlruter.

After the disaster of the Danish ship "Hans Hedtoft" an ice-central was established at Narssarssuaq responsible to the Meteorological Institute in Copenhagen (*Fabricius, 1965*). From this central air reconnaissance is carried out, generally twice a week. The ice occurrencies are plotted on a chart, which forms the basis for an ice report transmitted by radio on the termination of each flight. Besides these telegraphic reports the Meteorological Institute receives copies of all the original ice-charts, which enable us to outline rather detailed the behaviour of the ice.

Probably, within a few years infrared photographs from satellites will improve the ice patrol service and as a supplement to the reconnaissance from aircraft give still more detailed information about the extent of the ice.

Formerly, the Institute collected and dealt with information about the ice in all Arctic waters, but as a consequence of the enlarged heap of information from Greenland waters, the lack of information from the Soviet Arctic and the fact that compiled, rough-scale ice-charts of the entire Arctic are published by the *British Meteorological Office* in "The Marine Observer", the former publication "The State of the Ice in the Arctic Seas" is now succeeded by the publication "The Ice-conditions in the Greenland Waters", which only concerns the waters around Greenland but on the other hand gives much more details.

Computation of Ice Drift

From the ice-charts it is possible to observe the changes in the extent of ice and the concentrations and further, to get an impression of how fast the ice has drifted, but as we have no means to measure directly the rate at which the ice melts away, we cannot get an exact figure of the drift rate. Various attempts have been made to measure the speed directly but with little success. It has been tried to drop dye-stuff (esp. "Rhodamine B") upon icebergs and icefloes, but partly the berg or floe dyed cannot be spotted out between the others after a few days, even if an area of ab. 1000 sq.metres is dyed, and partly the dye-stuff will soon be covered with snow or follow the meltwater into the puddles. Another way to mark the ice is to drop sheets of orange-coloured plastic, but this has proved even less successful. A third way, and the best one, is to establish automatic radiobeacons on the ice, which is expensive, however, and the equipment needs inspection from time to time.

If we do succeed in marking an iceberg or a floe, we have another problem: The drift of the berg or floe in question will mostly not be representative, as the speed of the individual floes varies greatly. So, we will have to use indirect methods to compute the drift rates of the ice.

The extent and concentrations of the polar ice (storis) drifting southwards along the Greenland east coast in the East Greenland Current depend on two factors (fig. 4 and 5):

1. Oceanographic conditions. The actual extent and speed of the currents will greatly affect the ice-conditions. And the surface sea temperatures will partly be determining for the rate at which the ice will melt.

2. The meteorological conditions – primarily the wind – are of great importance, especially in the Kap Farvel region.

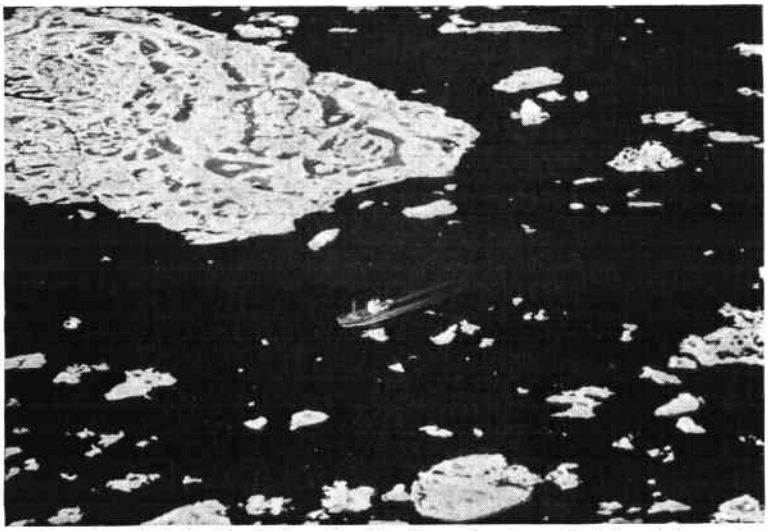


Fig. 2. The ship "Thala Dan", length abt. 85 m (centre of picture) is navigating between floes of different sizes off Mestersvig. The largest floe is about 500 m in width and probably almost 1 km long and is termed a "medium floe"; "big floes" exceed a size of 1 km. Floes of size near 10 km are not rare in this area, whereas they will always have broken down into smaller pieces before they reach Kap Farvel.

Fig. 2. „Thala Dan" (længde ca. 85 m) sejler ud for Mestersvig mellem flager af forskellig størrelse. Den største er ca. 500 m bred og formodentlig op imod 1 km lang; flager benævnes først store, når de overstiger 1 km. Flager på op imod 10 km er ikke sjældne så langt oppe ad kysten, hvorimod de altid vil være brækket i mindre stykker, inden de når Kap Farvel.

As we have normally no information about the actual oceanographic conditions we are referred to use statistical means, whereas we know the trends of the weather in broad outline for a given period.

If we have a period with varying weather situations, but with only slight changes in the ice-conditions, or a period with unchanged weather trend and great differences in the ice-conditions, these may be presumed to be owing to changes in the oceanographic conditions. Further, if during two periods the weather trends have been nearly identical but the movements of the ice have been different we may conclude that these differences are caused by changes in the oceanographic conditions.

If, on the other hand, we have a period with varying weather situations and great changes in the ice-conditions, or a period with unchanged weather trend and unchanged ice behaviour as well, we may conclude that the ice has been influenced mainly by the weather. On basis of sufficient statistical material we may therefore be able

Fig. 3. "Close-up" photo of drift ice (concentration 7/10) off Scoresby Sund May 19, 1962. The floes (the largest about 300 m long) are still partly snow-covered and have melt water puddles of 30—50 m in diameter. Further, old pressure ridges are seen, which are the last parts of the floes to melt away.

Fig. 3. „Nærbillede" af drivis (koncentration 7/10) ud for Scoresby Sund 19/5 1962. På de delvis snedækkede flager, hvoraf de største er ca. 300 m lange, ses ca. 30—50 m store smeltevandspytter. Endvidere ses rester af gamle skrueisvolde, som er de sidste, der smelter.

Fig. 4. Open and closed ice edge off Kong Oscars Fjord (Mestersvig). The closed ice edge with dense concentrations is caused by wind blowing from the right.

Fig. 4. Åben og lukket iskant ud for Kong Oscars Fjord (Mestersvig). Den lukkede iskant med de tætte koncentrationer er opstået ved, at vinden ude fra har blæst flagerne sammen.

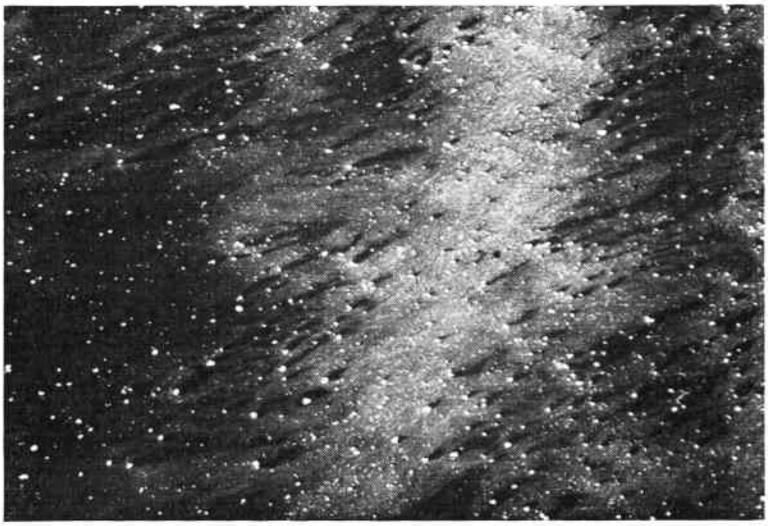


Fig. 5. Drift ice off Cape Cort Adeler (about 62° N) on the east coast, April 2, 1962. Altitude: 5000 ft. Direction: SE. The ice consists of small icebergs (white), bergy bits, small floes, brash and blocks. The light band in the middle is a belt of more dense concentratinns mainly of brash. The sea ice is drifting towards south at a larger rate than the icebergs. This appears from the dark stripes of open water to the right of the bergs.

Fig. 5. Drivis ud for østkysten ved Kap Cort Adeler (ca. 62° N) 2. april 1962 mod SØ fra 5000 fods højde. Isen består af små isfjelde (helt hvide), kalvis, små flager, skosser, isstumper og kvadderis. Den lyse stribe i midten er et bælte af tættere koncentrationer, overvejende kvadderis. Den øvrige is driver mod S med større hastighed end isfjeldene, jfr. de mørke striber af åbent vand til højre for disse.

to state the influence of the weather and of the oceanographic conditions resp. upon the drift of the ice.

Examples from 1961

The frequent meteorological depressions between Greenland and Iceland make northerly winds common along the southern east coast of Greenland. A preliminary attempt to show the influence of the wind is made on fig. 6 to 9 with some clear examples from the year 1961.

Fig. 6 shows 3 charts covering the Greenland east coast from Angmagssalik to Kap Farvel. The first chart outlines the ice-conditions south of 62°30' N on February 9 and north of this latitude on February 7. The second and the third chart give the ice-conditions on February 14 and 20-21 resp. The ice-concentrations are indicated by hatching as described in the legend.

It will be seen that the ice has extended far southwards in the

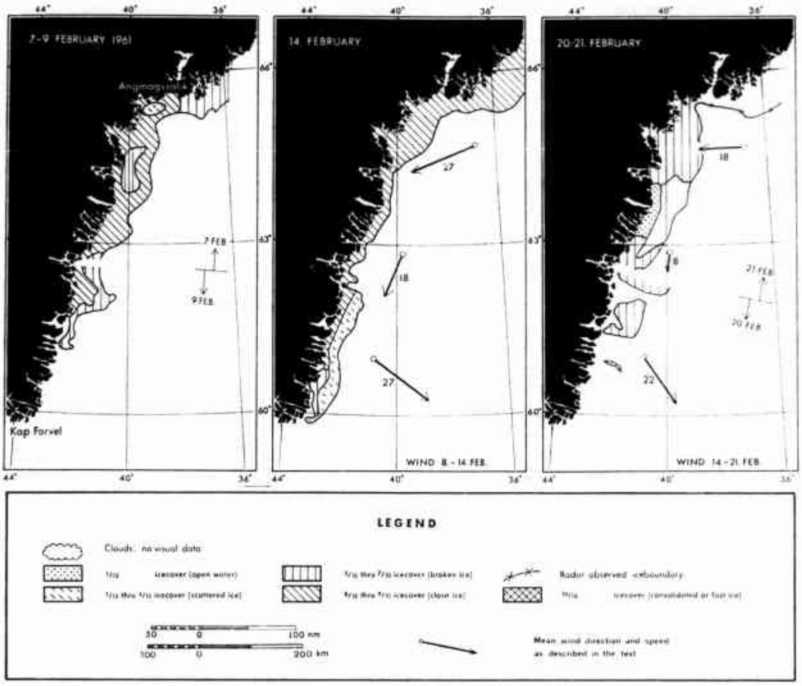


Fig. 6. The ice-conditions off the Greenland east coast between Angmagssalik and Kap Farvel on February 7—21, 1961.

Fig. 6. Isforholdene ud for den grønlandske østkyst mellem Angmagssalik og Kap Farvel 7.—21. februar 1961. Pilene med tal angiver retning og styrke (knob) af middelgradientvinden 3 steder, beregnet efter overfladevejrkortets isobarer. Mellem 7. og 14. februar var isen drevet mindst 16 sømil i døgnet (excl. hvad der er smeltet), og vinden skønnes at være af dominerende indflydelse. Mellem 14. og 21. februar var udbredelsen igen mindre — muligvis som følge af den svagere vindvektor ved 63° N.

period February 7-14, and receded again on February 20 – in fact the ice drifted about 16 nm a day and probably more, as we do not know how much ice has melted away; while the gradient sea current as a mean should be estimated to be about 7 nm a day according to the oceanographic atlases, the remaining 9 nm must be supposed to be wind-caused drift. On the charts of February 14 and February 20-21 the mean gradient wind is inserted in three places covering February 8-14 and February 14-21 resp., as computed from the sea level isobar-charts with 12 hours' interval. The mean speed in knots is also given. The arrows should give an indication of the wind influence, so that the speed of the surface wind over icefree sea should be about 20% less than the speed of the gradient wind, and the direction about 10° to the left. According to Browne and Crary

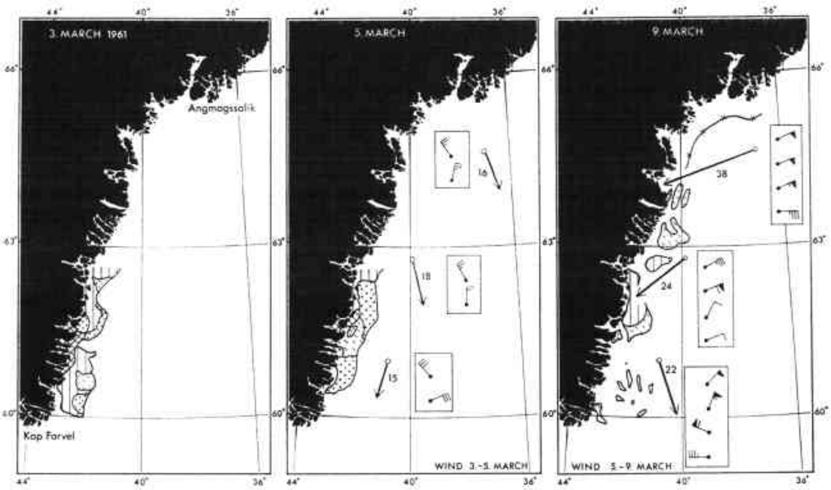


Fig. 7. The ice-conditions off the east coast between Angmagssalik and Kap Farvel on March 3—9, 1961.

Fig. 7. Isforholdene ud for østkysten mellem Angmagssalik og Kap Farvel 3.—9. marts 1961. På de to af kortene er foruden vektorerne for middelgradientvinden tillige i særskilte rammer indtegnet vindpile, hver repræsenterende gradientvinden i ét døgn. Hver ramme refererer til den nærliggende vektor, og på kortet i midten gælder rammernes øverste vindpil for den 3. marts eftermiddag og 4. marts formiddag, mens den anden (nederste) omfatter den 4. marts eftermiddag og 5. marts formiddag.

(1958) the surface wind over ice-covered sea should be regarded to have a deflection of about 40° to the left of the gradient wind, and the deviation of the ice drift is about 35° to the right of the surface wind. Therefore, the direction of the wind-caused ice drift should be close to the gradient or geostrophic wind direction.

Unfortunately, however, the winds near the coast differ fairly often from the surface winds farther out, partly because of the height and abruptness of the coast, and from the meteorological charts we cannot find out to which extent the coast affects the winds. Further, the mean wind vectors do not show whether they are resultants of strong winds from various directions or weak winds mainly from one direction, or whether strong winds have prevailed in the latter part of the period or the winds have been moderate during the whole period. Nevertheless, as the first step in the study of to which extent the meteorological conditions affect the ice-conditions the mean gradient wind arrows may be helpful.

From February 14 to 21 the southernmost wind vector is slightly diminished, while the northernmost is reduced by one third and directed true west, and the middle one is less than half the size ascertained February 14. As a consequence, the ice-belt at 64°N has widened, but the transport past 63°N was small so that all ice south of 61°N has drifted away into the warm Atlantic water and melted.

From fig. 7 it appears that the ice has receded from March 3 to 9. In addition to the mean gradient wind vectors from March 3 to 5 and from March 5 to 9 resp., the individual wind-arrows, each representing 24 hours, are put on two of the charts in separate frames. Each frame refers to the adjoining mean wind vector; e.g. on the chart in center the upper wind-arrow in each frame covers the period from March 3 at 12,00 GMT to March 4 at 12,00 GMT. while the lower one covers March 4 at 12,00 GMT to March 5 at 12,00 GMT. From March 5-9 the winds were very strong, especially along the coast where northerly gales prevailed due to a deep depression which moved in from south. Surely these winds caused a fast ice drift in the chart area, and therefore it might seem difficult to explain why nevertheless the ice receded during the period. Meanwhile, the winds north of 66°N had an easterly and partly southeasterly direction, probably causing only a small supply of drift ice into the chart area. This may be one of the reasons why the ice receded; another reason may be possible changes in the oceanographic conditions, which we do not know.

On fig. 8 is shown the ice and wind conditions off the coast between Angmagssalik and Nordre Aputiteq on July 11 to 27-28, and on August 17 to 24. During the former period the winds were on an average weak easterly (columns I and II corresponding to the wind-resultants on the upper, right chart) and the ice-belt decreased in width. Even during the latter period the width of the ice-belt decreased in spite of the relatively stronger north-easterly winds. This may be due to the winds north of the chart area being southeasterly, causing only moderate quantities of drift ice to move down into the area.

On fig. 9 is shown the periods April 14-21 and May 9-26. During the first period the ice is moving towards west in a long tongue, obviously because of the heavy north-easterly winds south and east of Kap Farvel. It is seen that the winds are much heavier here than in the bay, Julianehåb Bugt, which is quite normal with this wind direction. In fact, there will sometimes be a sharp line stretching from Kap Farvel towards southwest, east of which there will be real gales while the sea is completely quiet to the west of this line.

During the second period the ice moved to the south and west with a maximum around May 10 (on the respective chart the ice

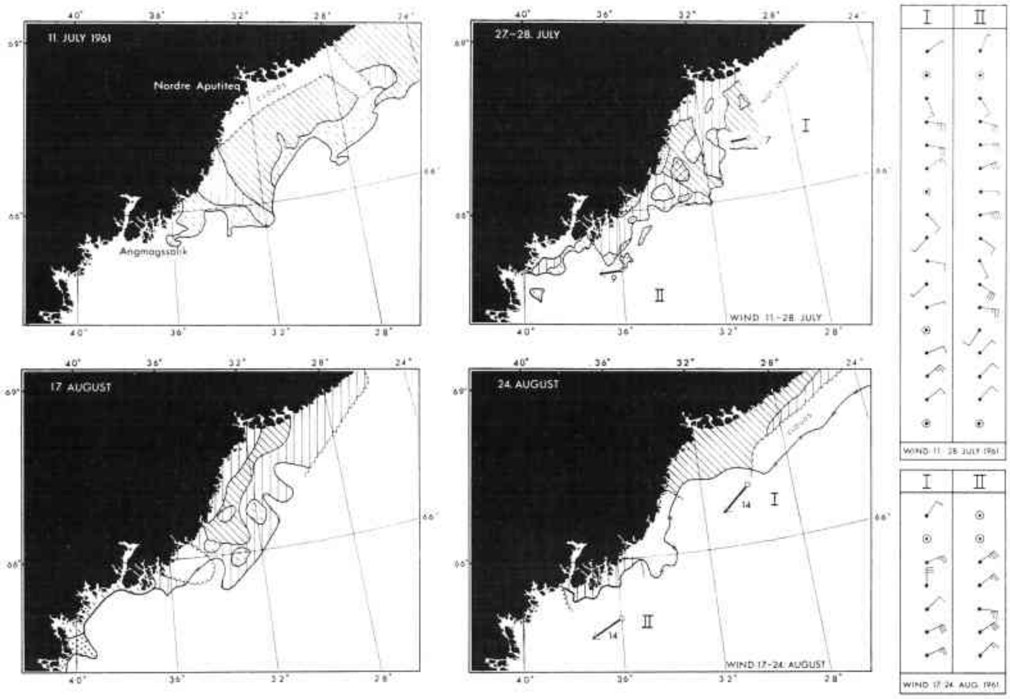
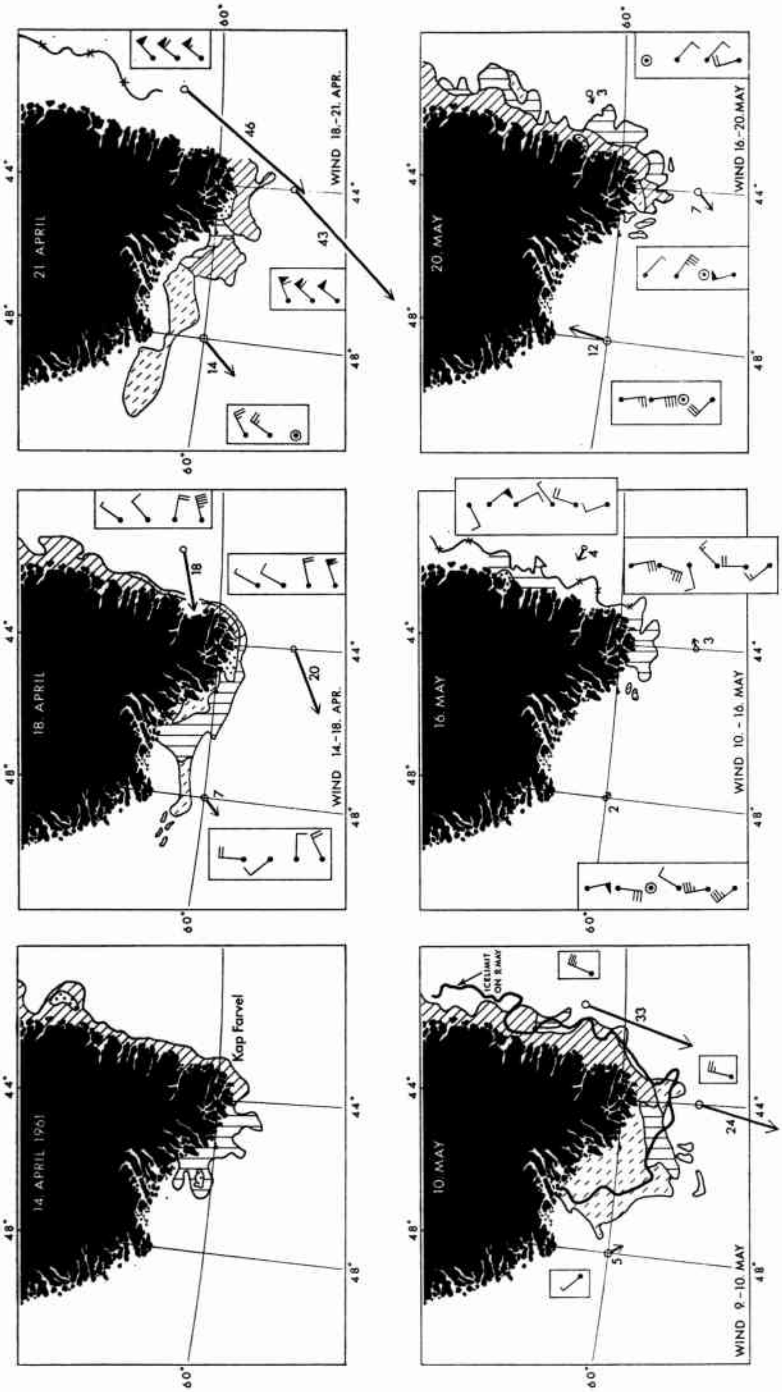


Fig. 8. The ice-conditions off the east coast between Angmagssalik and Nordre Aputiteq during the two periods from July 11—28 and August 17—24, resp.

Fig. 8. Isforholdene ved østkysten mellem Angmagssalik og Nordre Aputiteq i perioderne 11.—28. juli og 17.—24. august. I den første periode var vindene gennemgående svage, østlige (søjlerne I og II viser gradientvindene døgn for døgn perioden igennem de samme 2 steder, som de med mærket I og II indtegnede gennemsnits-vektorer angiver). I den anden periode var vindene gennemgående stærkere. I begge perioder er isbæltets bredde aftaget — sandsynligvis på grund af overvejende sydøstlige vinde nord for kortområdet, idet disse skønnes at have mindsket isdriften ned i området.

limit on May 9 is also indicated – with a heavy curve), while it receded to a minimum around May 16-20. Then it moved towards south again. The northerly strong winds east and south of Kap Farvel and the weak winds in the bay Julianehåb Bugt may account for the maximum around May 10, and the passing-by of cyclones causing weak wind-resultants from May 10-20 may explain the minimum on May 16-20. Later on north-westerly winds forced the ice further south. Yet the maximum on May 24 (the ice had moved more than 50 nm in 24 hours, excluded what may have melted away) is very difficult to explain when considering the wind change to increasing, southerly winds. It seems as if the ice has not yet reacted upon the sudden wind change but continued to move south-


14. APRIL 1961
Kap Farvel
18. APRIL
WIND 14.-18. APR.
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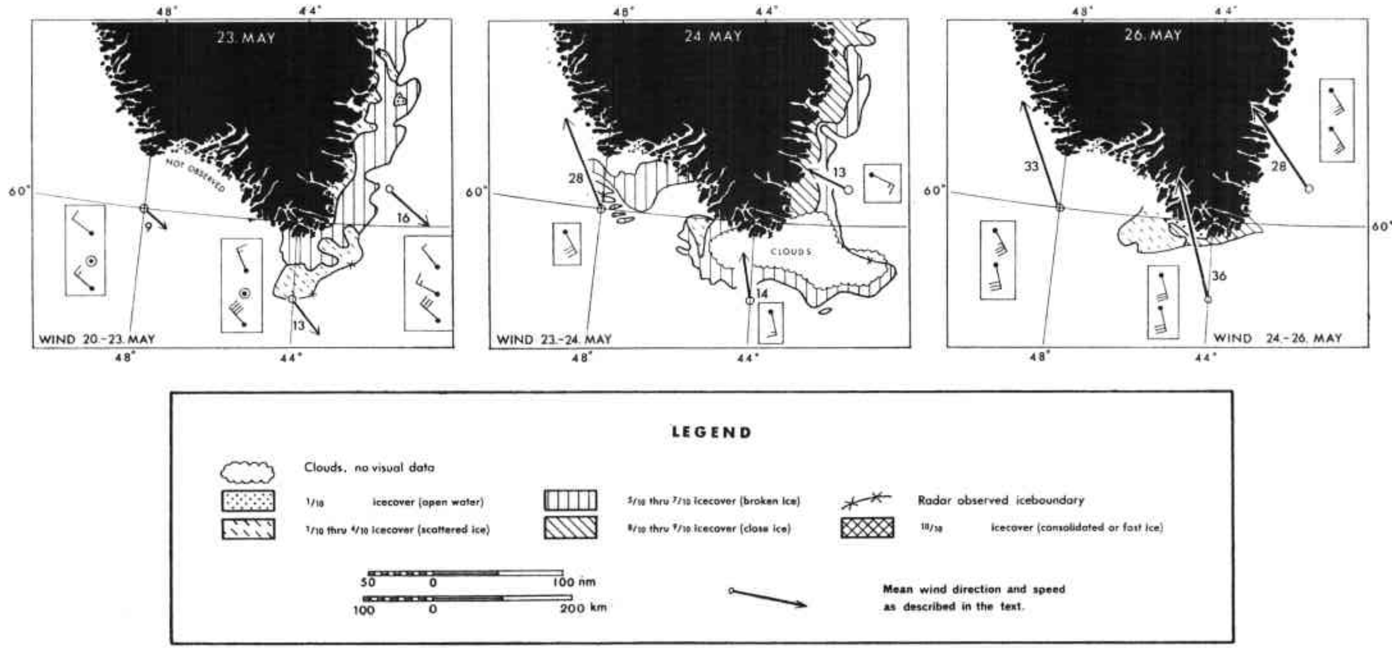

Fig. 9. The ice-conditions in the Kap Farvel area (from Frederikshåb on the west coast to Tingmiarmiut on the east coast) in the two periods from April 14 to 21 and from May 10 (9) to 26, resp.

Fig. 9. Isforholdene i Kap Farvel området i de to perioder 14.—21. april og 10. (9.)—26. maj. Se resuméet for nærmere forklaring.

wards in spite of this. This might indicate that the wind influenced not only the icefloes, but also the surface water – bringing the ice with it – which may need at little longer time to react. Another reason may be sudden changes in the currents. Such an explanation seems rather unlikely, yet we do not know much about the hydrography of the region. The interpretation of the atmospheric pressure patterns may be a little erroneous, so that the gradient winds derived from the meteorological surface-charts may not be completely representative. However, this should not change the pattern of the wind so much as to bring the full explanation. Another factor to recall is that the visibility on May 23 was poor so that some ice may actually have existed beyond the observed, but invisible on the radarscope in the aircraft it cannot have been large quantities. The bay, Julianehåb Bugt, was not reconnoitred on May 23 due to clouds, and probably the ice observed in the bay on May 24 was also present on the 23. On the chart outlining the ice on May 26 it is seen that on that date the ice had reacted upon the wind and receded.

Very little can be deduced from these few examples, but they may show the complexity of the ice movements and the difficulties in forecasting. Various computations have been made to find out the influence of wind, sea-currents, temperature etc. upon the sea ice in the Arctic, but it seems preferable to treat each region separately, the influence of many geographic environmental factors being unknown. It is intended later on to treat the observed data as shown on fig. 6 to 9 in order to be able to make 2-5 days forecasts for the shipping.

RESUMÉ

Meteorologisk Institut har i en årrække indsamlet og publiceret oplysninger om isforholdene i farvandene omkring Grønland begyndende med året 1890 i en årbog, der fra 1900 fik titlen „Isforholdene i de arktiske Have“ og omfattende hele det arktiske område. Siden påbegyndelsen af de amerikanske isrekognosceringer ud for Grønland og oprettelsen af en iscentral i Narssarssuaq i Sydgrønland, har oplysningerne fra de grønlandske farvande været betydeligt mere omfattende og detaillerede, hvorfor publikationsformen er blevet ændret til en ny årbog med titlen „Isforholdene i de grønlandske Farvande“.

Vindforholdene i Sydgrønland er domineret af de hyppigt passerende lavtryk. I artiklens fig. 6-9 gives nogle eksempler fra året 1961 på vindens indflydelse på isdriften. Der er her benyttet de beregnede gradientvinde (geostrofiske vinde), idet de aktuelle vinde ikke kendes. De mest interes-

sante eksempler gengives på fig. 9 og omfatter perioderne 14.-21. april og 9.-26. maj.

I den førstnævnte periode (fig. 9) strækker isen sig vest på i en lang tunge øjensynligt på grund af de kraftige nordøstlige vinde syd og øst for Kap Farvel. Det ses, at vindene er meget kraftigere der end i Julianehåb Bugt, hvilket er ret almindeligt med denne vindretning – ofte ses endda en skarp grænse fra Kap Farvel mod sydvest med kraftige vinde og oprørt hav øst for og rolig sø vest for.

I den anden periode (fig. 9) havde isen maximum omkring 10. maj og 24. maj og minimum omkring 16. maj. Disse variationer skyldes formodentlig først og fremmest vindforholdene; men det er interessant at bemærke den store udbredelse den 24. maj, hvor det synes, som om isen endnu ikke havde reageret på vindskiftet fra nordvest til sydøst. Ved rekognosceringen den 25. maj havde isen „trukket sig tilbage". Der blev ikke rekognosceret andre dage i perioderne, end dem kortene gengiver isudbredelsen fra.

Det er hensigten senere at bearbejde store dele af observationsmaterialet på lignende måde – område for område – for at se, hvilke love isdriften følger i de respektive områder med henblik på senere at kunne udarbejde 2-5 dages isprognoser til skibsfarten.

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