THE ICE CONDITIONS IN DAVIS STRAIT APRIL 3-21 1979 as interpreted from APT satellite images

HANS H. VALEUR

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A pilot study on the feasibility of APT images as a tool in mapping the sea ice occurrences has been performed as a part of the Danish-Canadian SURSAT Ice Experiment.

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The purpose of the investigation was tripple.

A. To outline the iceconditions as background information to the detailled field investigation around 68°20 N, 56° W on April 9-10.
B. To evaluate the feasibility of the satellite images, including a comparison between various imagesystems and a comparison between these and data from airborne remote sensors and with visual data from airborne observers.
C. Test of drift- and icegrowth models.

SOURCES

1. Landsat MSS images from ISIS, Canada.
2. TIROS-N AVHRR images from AES, SDL, Canada.
3. TIROS-N AVHRR images from NOAA, NESS, USA.
4. TIROS-N AVHRR images from the space observatory near Copenhagen.
5. NOAA 5 VHRR images from NOAA, NESS, USA.
6. METEOR 2 images from the space observatory near Copenhagen.
7. NIMBUS G data from microwave scanning radiometres supplied by NASA, USA.

The above mentioned sources were the planned ones. However, their number was reduced substantially due to the following circumstances.

Ad. 1. The Landsat MSS system was out of control in the period in question whence no data were received.
Ad. 2. SDL (AES Satellite Data Laboratory) used to produce excellent APT products, but had still tecnical troubles with the implementation of the digital image format processing system and was unable to supply high quality TIROS-N data in the investigation period.
AD. 3. NOAA, NESS (National Environmental Satellite Service) kindly supplied us currently with images from the investigation period, both vis. and IR.

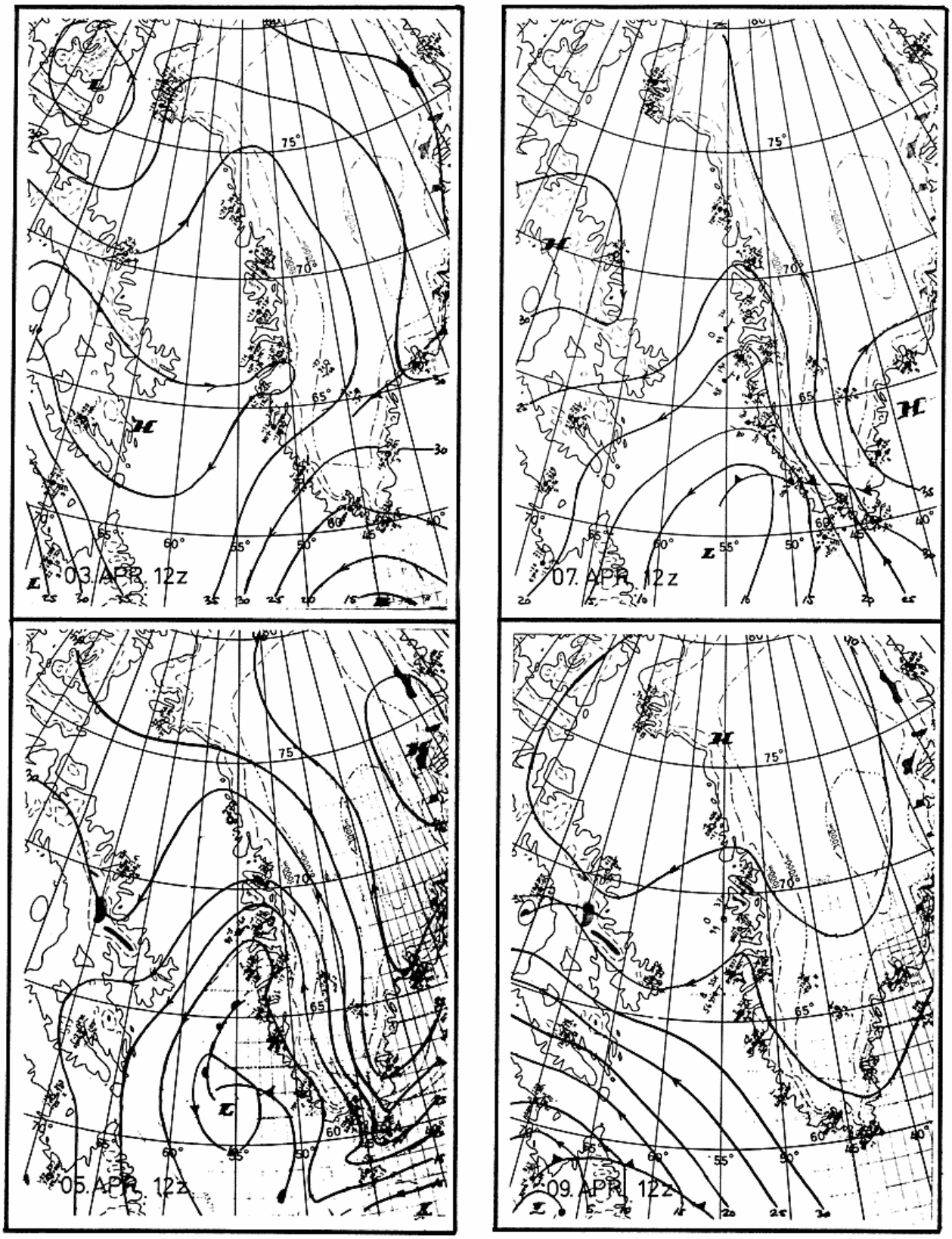
Although the images are of an excellent quality, the test area, however, is situated so near the edge af the images that the geometrical distortion is rendering them less adequate as basic material. The images, therefore, are used as support in interpreting the products from source No. 6.
Ad. 4. The observatory had still technical troubles in the implementation of the digital processing equipment and was unable to supply AVHRR images from the period.
Ad. 5. The NOAA 5 satellite was switched off in February.
Ad. 6. The Sovjet satellite METEOR 2 has transmitted images of very high quality similar to the American APT system and the analysis is primarily based on these images supplied with information from source No. 3 as mentioned above.
Ad. 7. Data from this system have not been collected by Met. Inst., but reception of available material is being taken care of by EMI (Elektromagnetics Institute, Technical University of Denmark) for later processing.

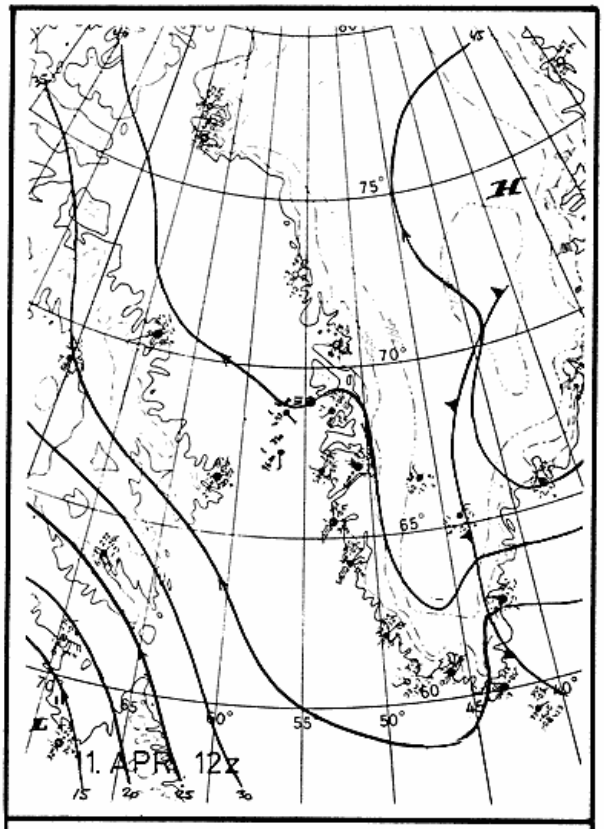
OUTLINE OF THE WEATHERCONDITIONS IN DAVIS STRAIT BETWEEN 64° N AND 68° N IN THE PERIOD OF INVESTIGATION

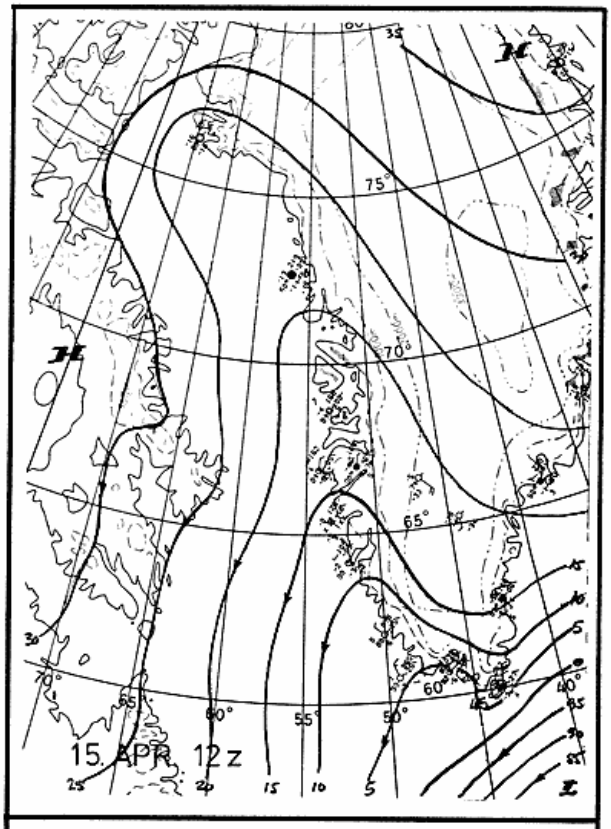
The description is based on re-analyzed 6 hourly synoptic weather-charts. The analysis was made by Mr. Leif Rasmussen, class II meteorologist. Noon-charts are reproduced as fig. 1.

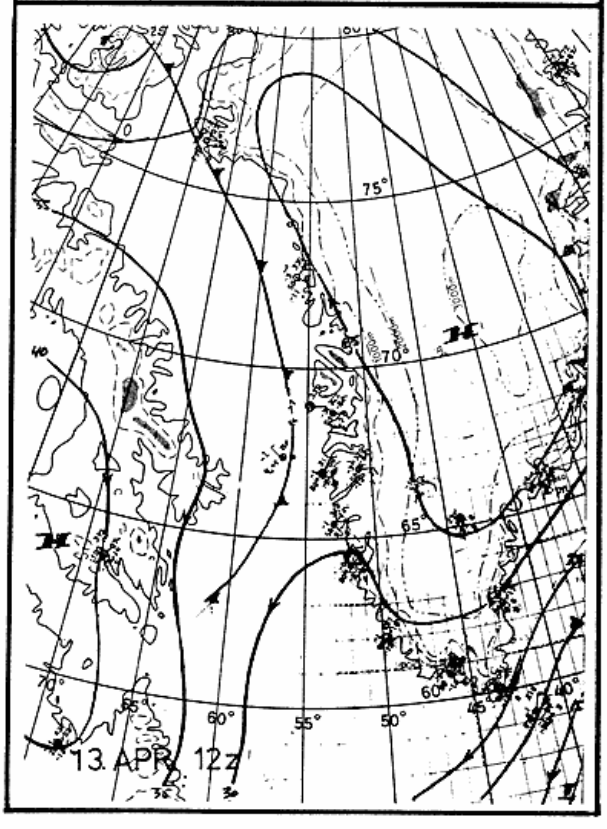
Throughout the period the weather was characterized by an unusually high degree of instability for the time of the year. As a consequence the cloudcover was very extensive consisting mostly of a more or less cumiliform type which complicated or even impeded the image interpretation. Furthermore, the period did not include plain weathersituations of longer duration which could facilitate the interpretation and test of models. So, the period is choosen with the aim of providing a generel back-up to the SURSAT-project.

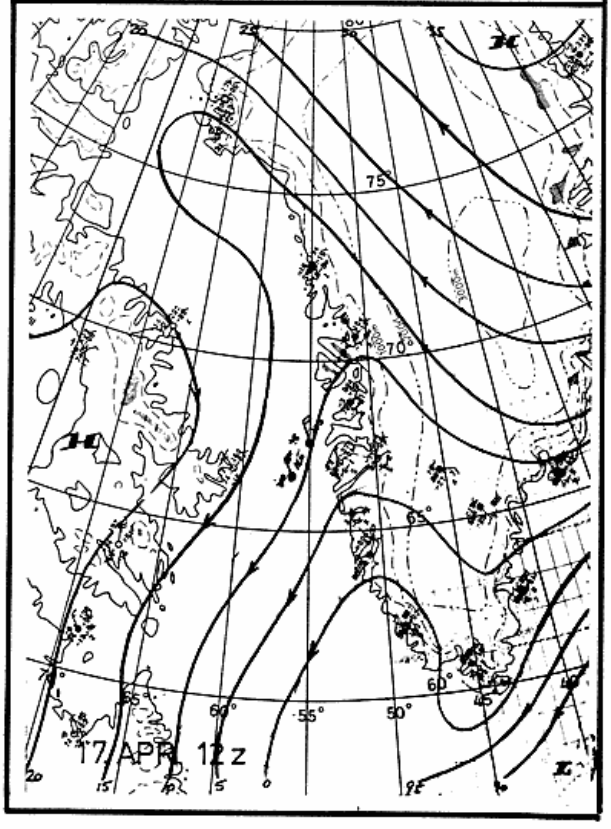
On April 3 an E-W situated pressure ridge across the Davis Strait gave southwesterly towards north turning cold winds in the northernmost part of the area, while the wind came from a northeastly direction in the southernmost part.

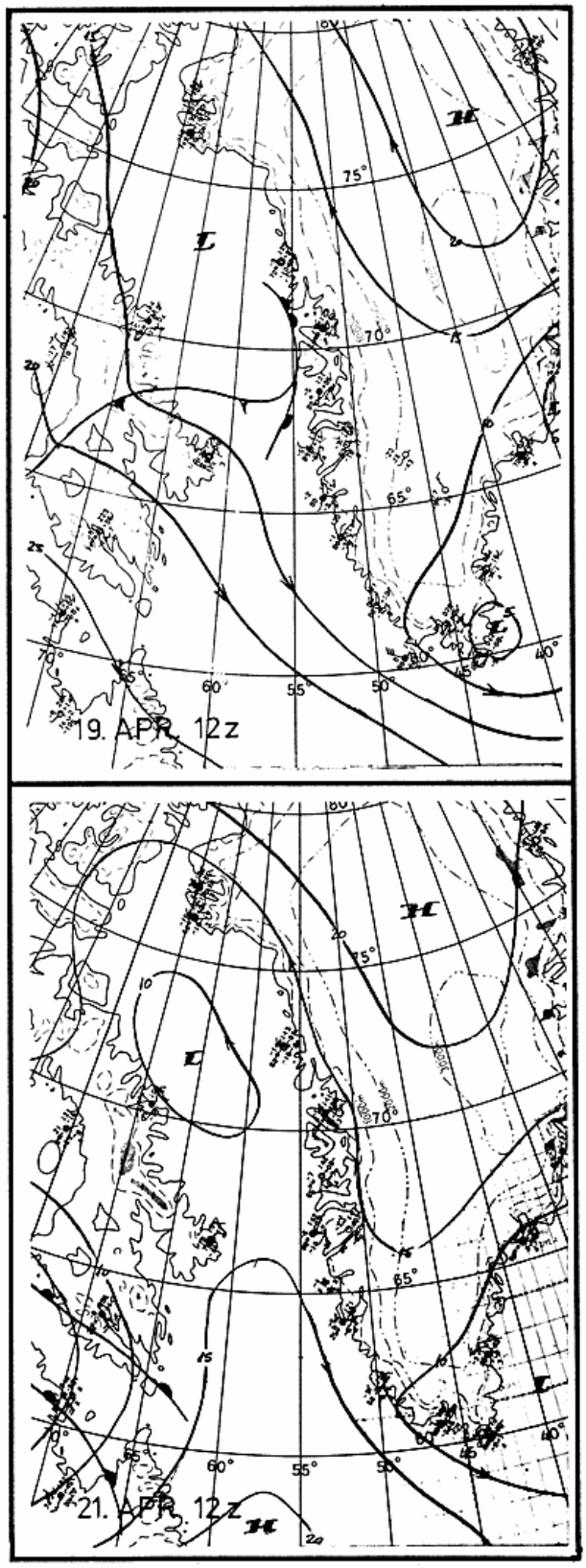

03. APR. 12z
07. APR. 12z
05. APR. 12z
09. APR. 12z


11. APR. 12z


15. APR. 12z


13. APR. 12z


17. APR. 12z



During April 4-5 the high pressure moved northward and a low pressure trough coming up from the south gave north-easterly winds and cold weather the following days.

On April 8 the low was filled and the following 4 days gave relatively warm weather with southerly winds, yet in the northern part winds from NE.

On April 13 a new low pressure trough moved up from the south while deepening. The whole area had winds between NW and NE during the following 4-5 days, the weather getting colder anew. Thereafter the pressure gradient diminished, and during the remainder period weak northerly winds prevailed.

The present analysis reconfirmed the almost total lack of weather data from the open sea.

THE ICE CONDITIONS

The iceconditions showed the distribution typical for the time of the year with minor daily variations and the ice edge generelly receeding from the Greenland coast during the month. (see fig. 2.)

At the beginning of the period (April 3) the iceconditions were normal, the edge of the westice (Danish term for Baffin Bay first year ice) being situated near the coast at 68° 30 N. South of this latitude the distance between the ice edge and the coastline increased, becoming 80 nm off 65° N. On the icechart from that date the US FLEWEAFAC (Fleet Weather Facility) produced icechart from April 1-3 has been added in a heavy dot-and-dash line.

On April 4 the ice edge at lat. 68° N seemed to be situated 25 nm closer to the coastline than on the day before due to prevailing westerly winds the preceeding 24 hours (SW 15-20, rapidly decreasing to 5 knots, thereafter becoming NW and N). However, very low temperature and snowshowers rendered extensive nilasformations probable (the term »nilas« is being used in the present report as a common term for new ice, pancake ice and nilas). Further, the defining of the ice edge on April 3 was very ambiguous, so ice might have been present without being indicated on the chart. The apparent movement 20 nm westward of the ice edge at 69° N cannot be explained by the windconditions. More likely the edge from April 3 has been indicated too easterly due to snowshowers and snowcovered sea surface being interpreted as sea ice.

On April 5 the ice extent seemed nearly unchanged in spite of rather strong winds from NE (15-20 knots) particularly at some distance from the coast. Between 66° and 68° N nilas has apparently been formed up to 20 nm more easterly than on the day before. The cold weather (÷ 10 centigrades reported by a ship) makes this interpretation probable.

April 6-8: interpretation fully impeded by cloudcover.

On April 9 the iceconditions were nearly unchanged, yet at 66° 30 N the ice edge seems to have moved 25 nm to the west, which can be explained only partly by the relatively warm weather with prevailing weak easterly winds the previous days. A heavy dot-and-dash line on the chart is inserted to indicate the ice edge as reported by the Canadian Ice Branch.

April 10: Iceconditions were nearly unchanged.

April 11: Interpretation fully impeded by cloudcover.

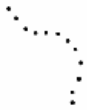
Fig. 1: The weather conditions in Davis Strait during the investigation period.
Fig. 1: Vejret i Davisstrædet i undersøgelsesperioden.

FIG 2.

SIGNATURFORKLARING
LEGEND

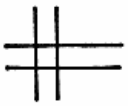
8/10 Vinteris
First year ice, concentration 8 tenths

6/10 tyndis (eller evt. vinteris af gan-ske ringe tæthed). Iskanten delvist vist.
Nilas, concentration 6 tenths, (or first year ice of much lower concentration). Ice edge/boundary partly estimated.

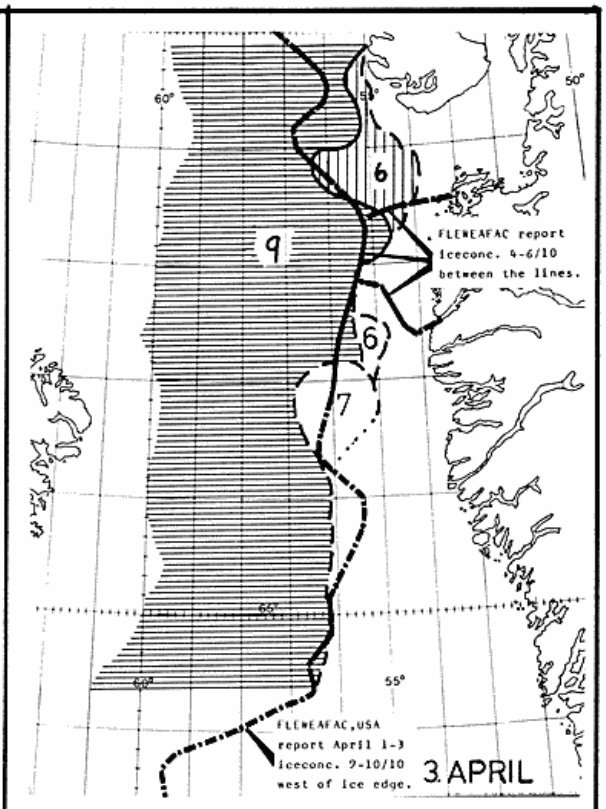


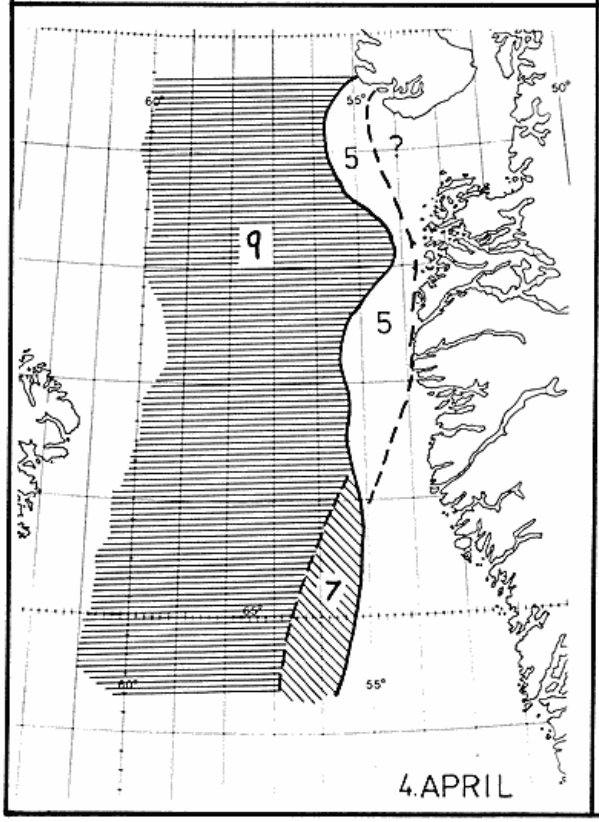
Iskantens beliggenhed beregnet indirekte ud fra isforholdene i de omkringliggende døgn.
Ice edge/ ice boundary deduced from preceding and/or subsequent ice conditions.

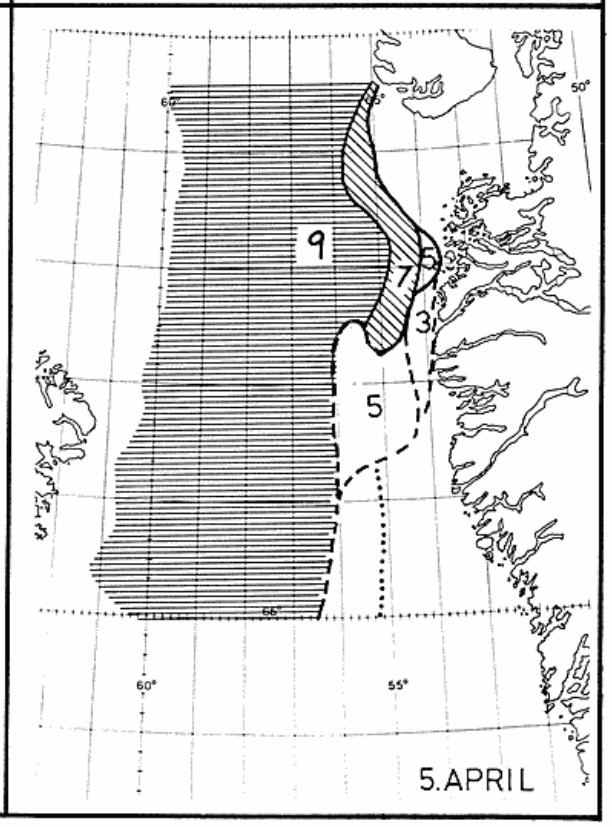
Iskant oplyst fra udenlandske kilder.
Ice edge/ice boundary as reported from indicated foreign services.

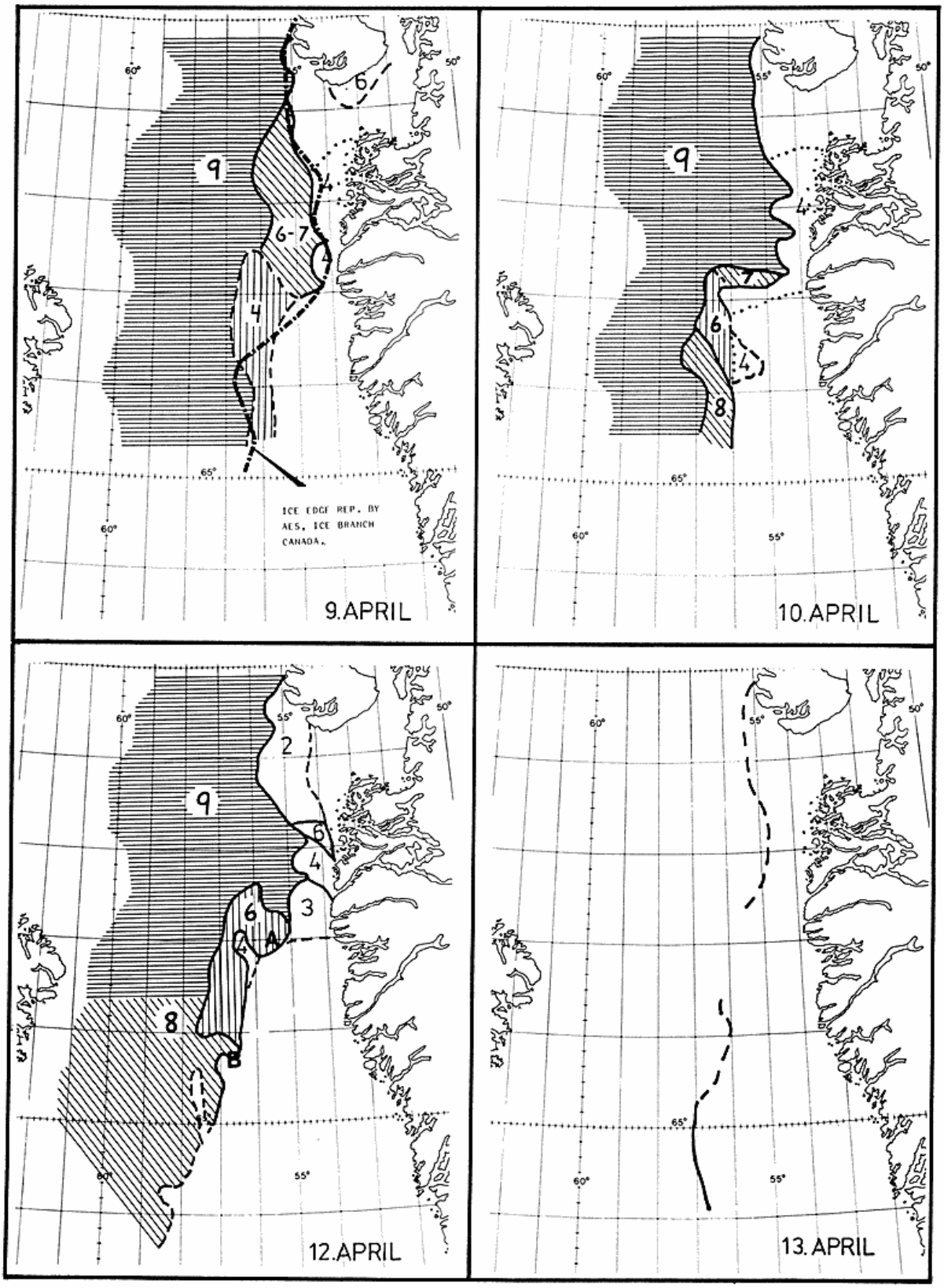


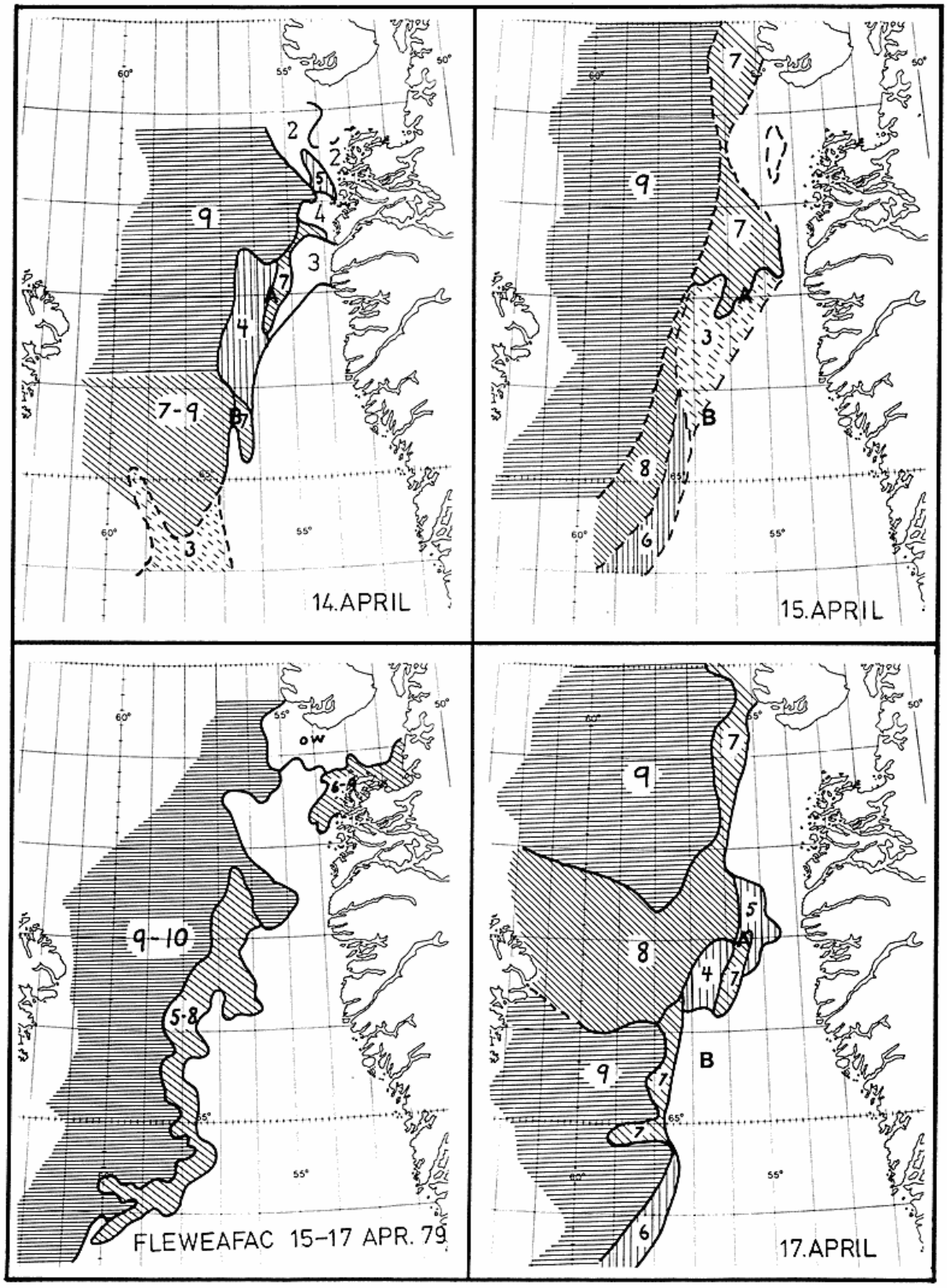
Prøvefelt 9-10 april.
Test site April 9-10.

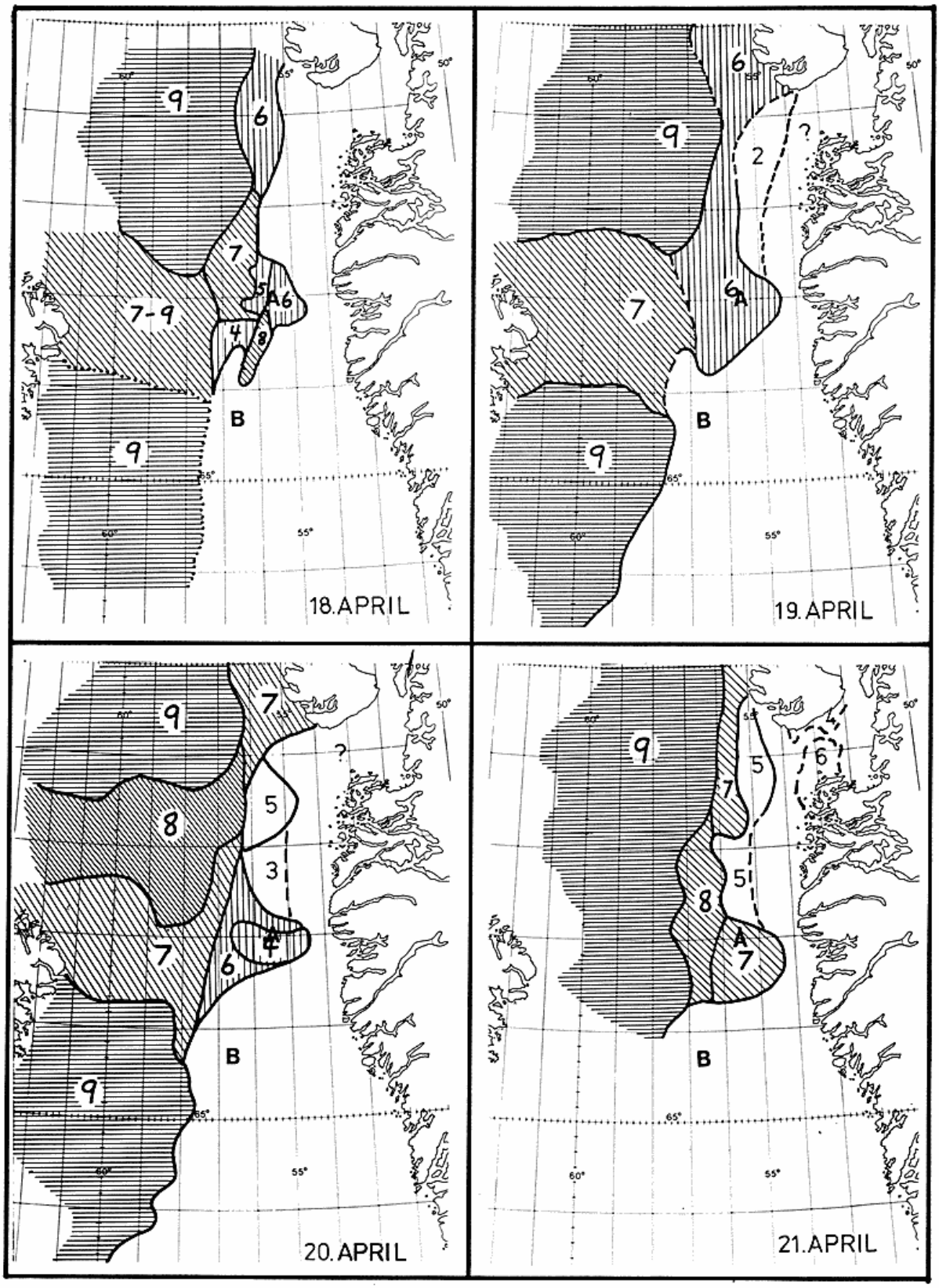







9
6
6-7
4
ICE EDGE REP. BY
AES, ICE BRANCH
CANADA.
9.APRIL
10.APRIL
12.APRIL
13. APRIL
2
3
8
A
B


14.APRIL
15.APRIL
FLEWEAFAC 15–17 APR. 79
17.APRIL
ow
B


18.APRIL
19.APRIL
20.APRIL
21.APRIL
B

On April 12 a fringe of nilas (?) to the east of the west ice off Disko Bay probably has its origin in Disko Bay having been blown out by the prevailing northeasterly winds during the previous day. Otherwise the conditions seem to be largely unchanged.

On April 13 only the edge of the ice can be identified and only faintly through the clouds. The situation seems rather unchanged.

On April 14 the iceconditions were nearly unchanged. The icetongues at A and B on the chart are clearly visible on the images and may be due to possible negative eddies in the sea. At least the weak winds during the previous days cannot be the explanation.

April 16. Interpretation totally impeded by cloudover.

Between the charts from April 15 and 17 resp., a chart showing the iceconditions on April 15-17 as indicated by US FLEWEAFAC has been inserted.

April 17. The strong northerly winds up to 40 knots during the previous day seems to have caused the ice to drift 15-30 nm to the south. Otherwise the conditions were unchanged.

April 18. The wind had decreased and remainded below 20 knots through the previous day. The ice had drifted ab. 15 nm to the south. Otherwise the conditions were unchanged.

April 19. The ice conditions nearly unchanged. The indicated nilas between 67° and 69° N might partly be mistaken snowcovered grease. However, the indicated is in agreement with the conditions on the following days.

April 20. The iceconditions nearly unchanged.

April 21. The iceconditions nearly unchanged, yet the tongue at 67° N seems to have moved ab. 15 nm to the south, probably due to the at times strong winds during the foregoing days.

Concerning the influence of the wind only the influence of the strong northerly winds could be noted, otherwise it was extremely difficult in this investigation to trace the windcaused drift. Probably the windcaused fluctuations of the ice edge have been of the same order of magnitude as the errorlimits in the interpretation, since clouds generally obscured the satellite image of the period. It was virtually impossible to identify single floes or patches of floes, which could be traced on several consecutive days and state exactly the icemovement.

Further, it should be noted that the quality of the images did not enable the interpreter to distinguish between first year ice of very low concentration and younger ice categories of higher concentration. In this respect the interpretation is based on experience from other years. Because we wished to get an impression of the validity of unsupported interpretation of the satellite images, I have in no cases let the interpretation be supported by the aerial reconnaissances. The most apparent discrepancy seems to be the nilas occurences on April 11 which were not identified on the satellite image.

AERIAL ICE RECONNAISSANCES

Fig. 3 shows the ice conditions as recorded by the Danish ice reconnaissance flights. The charts based on satellite image interpretation correspond fairly well with these charts. Besides, in addition, the reconnaissance charts tend to show that the shortterm variations on the ice extent is of the same order of magnitude as was derived from the satellite images.

CONCLUSIONS

The following may be concluded:

1. The investigation reconfirmed that proper interpretation of the satellite images is possible only in connexion with substantial knowledge of the weather conditions.
2. Interpretation is possible only when comparison is beeing made backwards in time.
3. New ice, nilas, pancake ice or scattered strips of older ice was generelly not visible through even a very thin stratiform cloudcover.
4. In spite of the unusually bad weather for that time of the year (extensive cumuliform clouds rendered the images extremely difficult to interpret) it was possible to identify the iceconditions sufficiently accurate so as to meet the maritime planning requirement. On the other hand the degree of accuracy in specifying the positioning of the ice edges and concentrations from the images seems to be of the same order of magnitude as the day to day variations in the iceconditions.
5. Conventional aerial reconnaissances in periods with a dense cumuliform cloudcover could give information on ice edges by means of radar, but could not add substantial information regarding icetypes or -concentration unless spotwise diving to visual observation was made.
6. Concerning the fulfilment of the indicated purposes it can be concluded that:
   Purpose A was not meet with fully satisfactorily neither by the image interpretation nor by the reconnaissances.
   Purpose B was fulfilled with respect to conventional image interpretation, whereas any digital image processing was not executed.
   Purpose C was not fulfilled since the cloudcover made the positioning of the ice edge too unreliable and since the structure of the ice was to faint as to allow identification of single floes or patches and thereby allow exact drift studies.

PROPOSED SUPPLEMENTARY DATASOURCES AND/OR PROCESSING

In spite of the fact that the investigation period, as mentioned before, was chosen aiming to give a back'up to the SURSAT-project, only, the investigation did indicate/confirm that the information could be improved by the following ways of processing and/or by the following supplementary data in the indicated priority sequence (which pays also attention to the costs).

1. Increased possibility to seperate by optional amendment of the grey-tone scale (a sort of density slicing) will definitely facilitate the differentiation of ice and clouds in the images. (see fig. 4 a+b). Such a slicing facility combined with a false color TV display is expected to be in operation at the Rude Skov space observatory before the end of 1980.

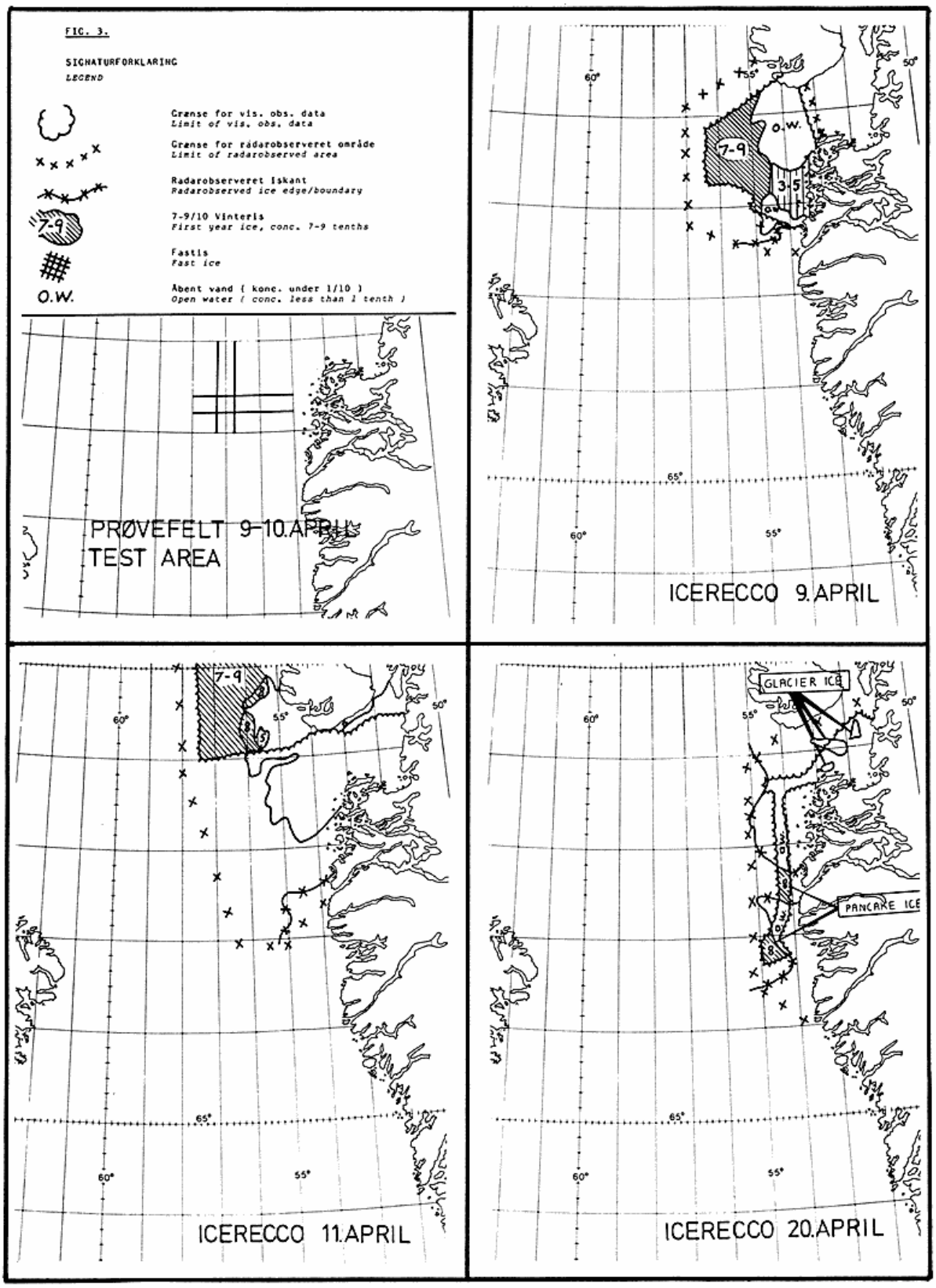


FIG. 3.
SIGNATURFORKLARING
LEGEND
Grænse for vis. obs. data
Limit of vis. obs. data
Grænse for rådarobserveret område
Limit of radarobserved area
Radarobserveret iskant
Radarobserved ice edge/boundary
7-9/10 Vinteris
First year ice, conc. 7-9 tenths
Fastis
Fast ice
O.W.
Åbent vand (konc. under 1/10)
Open water (conc. less than 1 tenth)
7-9
PRØVEFELT 9-10.APRIL
TEST AREA
ICERECCO 9.APRIL
ICERECCO 11.APRIL
GLACIER ICE
PANCAKE ICE
ICERECCO 20.APRIL

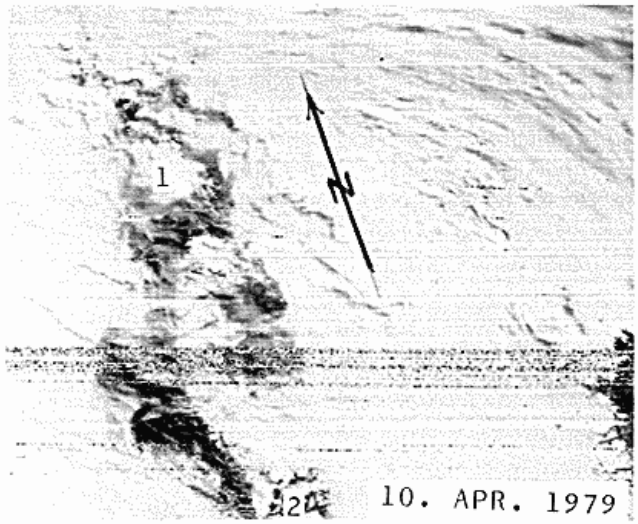


Fig. 4 a: METEOR 'APT' image from Apr. 10 at 6:25 pm GMT. Here, density slicing of the image would certainly help, however, only use of SLR-data would probably render the ice classification unambiguous. '1' = Disko (island). '2' = Godthaab.

Fig. 4 a: METEOR satellitbillede 10. april kl. 18.25 z. Her vil en »density slicing« gøre uderværker. Men kun SLR-data forventes at ville kunne give en sikker isklassificering. '1' = øen Disko. '2' = Godthåb.

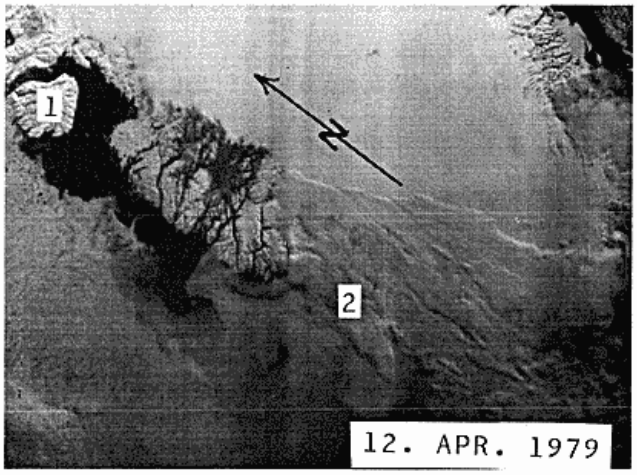


Fig. 4 b: METEOR 'APT' image from Apr. 12 at 9:13 am GMT. Density slicing would most probably even make the sporadic ice occurences in Disko Bay clearly visible. Further, vector-classification should make it possible to distinguish between the various ice types, whereas, additionally, use of microwave data (active and passive) is not expected to yield new information of operational importance.

Fig. 4 b: METEOR satellitbillede 12. april kl. 09.13 z. En »density slicing« vil sikkert også få isen i Disko Bugt bragt frem. Endvidere vil en vektorklassificering sikkert muliggøre skel mellem forskellige istyper, mens anvendelse af mikrobølgedata her næppe vil bringe yderligere information frem.

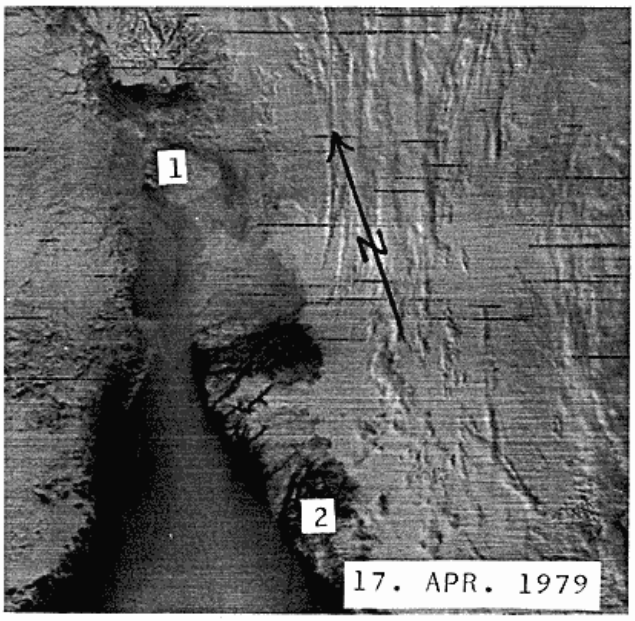


Fig. 4 c: METEOR 'APT' image from Apr. 17 at 6:16pm GMT. The image is supplying the interpreter with virtually all warranted information, yet passive microwave imagery of the area between the coast line and the pack ice edge would give reliable information on possible existance of a nilascover. On the other hand neither density slicing nor vectorclassification are expected to increase the interpretation possibilities in this image.

Fig. 4 c: METEOR satellitbillede 17. april kl. 18.16 z. Billedet giver næsten al den information, man kunne ønske sig, dog ville anvendelse af mikrobølgedata for området mellem kysten og vestisen give sikker information m.h.t. tilstedeværelse af tyndis. Derimod forventes hverken »density slicing« eller vektorklassificering at øge tolkningsmulighederne i dette område.

Date (in april)	Quality	Date (in april)	Quality
3rd	3	12th	1
4th	3	13th	4.5
5th	1 and 4	14th	2 and 1
6th	5	15th	4
7th	2 and 5	16th	3
8th	5	17th	1
9th	2 and 4	18th	1 and 5
10th	3 and 4	19th	4
11th	3	20th	3
		21st	3

Table 1. Quality classification of the available TIROS-N AVHRR and METEOR APT satellite images.
1 = ice edge clearly distinguishable and the ice concentration can be stated.
5 = ice edge impossible to identify.
2 and 5 = in part of the area the ice edge is fairly easy to distinguish, in another part of the area it is impossible to identify.
4.5 = quality between 4 and 5.

Tabel 1. Kvalitetsklassificering af de for perioden tilgængelige TIROS-N AVHRR og METEOR APT satellitbilleder.
1 = iskanten er helt tydelig, og iskoncentrationen kan bedømmes.
5 = iskanten umulig at skelne.
2 and 5 = i en del af området er iskanten ret tydelig, i en del af det umulig at skelne.
4.5 = kvalitet mellem 4 og 5.

2. Supplementary data from scanning microwave sensors as in the NIMBUS-G satellite would also increase the ability to distinguish between ice and clouds and to discover ice under the clouds, even if the resolution is no better than 25x25 km. (see fig. 4 c).
3. Improving of the weatherdata by placing a few weather bouys in Davis Strait would probably be the best means to provide reliable information on the windconditions and to compute the thickness of the pack ice which cannot be obtained operationally by any known remote sensing technique so far, due to i.a. the brine content of the ice.
4. Satellite images with a higher resolution as e.g. the LANDSAT MSS images would also in some cases improve the information since the structure of the ice may render it distinguishable from clouds. However, the frequency of coverage is a substantial limitation.
5. Through a combination af several spectral channels a vector-classification can be executed and thereby enable the interpreter to distinguish between several ice categories (see fig. 4 b), but in case of a close cloudcover this procedure will, of course, not add any information.
6. Application af SLR (Side Looking Radar) will due to its independance of the weather conditions most reliably give information on ice distribution and -topography, yet even this equipment will not supply any exact information on the thickness of the pack ice and due to its high cost the application of this sensing system will at present be spotwise. However, if the interpreter at a reasonable cost can get access to optional almost real time SLR-data from small areas, selected by him in each case, it goes without saying that the priority of those data will rank far higher (as No. 1 or 2).

RESUME

Af undersøgelsen synes at kunne konkluderes følgende:

1. Den bekræftede at tolkning af satellitbilleder kun er mulig i forbindelse med kendskab til vejrforholdene.
2. Tolkning er kun mulig såfremt man har mulighed for at sammenligne bagud.
3. Tyndis eller tallerkenis eller spredte revler af ældre is er normalt ikke synligt gennem skydække, selvom dette er ganske tyndt, stratiformt.
4. Trods en vejrmæssigt efter årstiden usædvanlig dårlig periode (mange cumuliforme skyer gjorde billederne meget vanskeligt tilgængelige), var det alligevel muligt at bestemme isforholdene tilstrækkeligt eksakt til planlægningsformål. Derimod er usikkerheden i fastlæggelse af iskanter og iskoncentration nok af samme størrelsesorden som dag til dag variationerne i isforholdene.
5. Konventionel flyisrekognoscering i situationer med tæt cumuliformt skydække kunne ikke supplere med væsentlige data m.h.t. oplysninger om istyper eller iskoncentrationer, men kun (v. hj. af radar) m.h.t. beliggenhed af iskanter, med mindre der foretages spotvise dyk til visuel observation.
6. M.h.t. opfyldelsen af de ved undersøgelsens stillede formål, må det konkluderes at formål A ikke blev opfyldt fuldt tilfredsstillende, hverken ved satellitbilledetolkningen eller ved flyrekognosceringerne.
   Formål B blev opfyldt, hvad angår konventionelle satellitbilleder, hvorimod digital billedbehandling ikke har fundet sted.
   Formål C blev ikke opfyldt, idet skydække gjorde iskantens beliggenhed for usikker, og idet isens struktur var for diffus til at enkeltflager eller grupper af samme kunne identificeres og derved muliggøre eksakte driftsstudier.