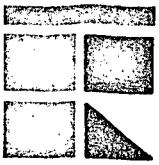

REF: 073-003-113

ERT Doc. P-408-4

21 March 1973

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Attention: Mr. James R. Greaves
ERTS Scientific Monitor, Code 651

Subject: ERTS-A Investigation No. SR126: Evaluate the Application of ERTS-A Data for Detecting and Mapping Sea Ice

Principal Investigator: James C. Barnes, PR525

Gentlemen:

This is the third bimonthly Type I Progress Report describing work performed by Environmental Research & Technology, Inc. (ERT), for the National Aeronautics and Space Administration under Contract No. NAS 5-21802. This report covers the period from 31 December 1972 to 28 February 1973.

The purpose of this investigation is to evaluate the application of imagery from the ERTS-A RBV and MSS sensors for surveillance of sea ice. The objectives are: to determine the spectral interval most suitable for ice survey; to measure the scale and types of ice features that can be detected; and to develop simplified interpretive techniques for differentiating ice from cloud and for mapping ice features. The results will enable the maximum use of data from ERTS and future spacecraft systems for operational ship routing, compilation of ice charts, and scientific research.

A. ACCOMPLISHMENTS DURING REPORTING PERIOD

1. ERTS Data Sample

Because of the winter darkness at high latitudes, no new ERTS data were received through the standing order procedure during this reporting period. The total data sample, therefore, is that which is listed in the previous progress report ("Use of ERTS Data for Mapping Arctic Sea Ice," Type II Report, February 1973). The nearly 70 ERTS passes in which significant amounts of sea ice can be identified are from the period between late July and late October 1972. The majority of the useful scenes are in the eastern Beaufort Sea - Banks Island area; other scenes cover various parts of the Canadian Archipelago, Baffin Bay, and the Greenland Sea along the east coast of Greenland.

DISCIPLINE: MARINE RESOURCES AND OCEAN SURVEYS, SEA ICE MONITORING

TITLE: EVALUATE THE APPLICATION OF ERTS-A DATA FOR DETECTING AND MAPPING SEA ICE (SR NO. 126)

PRINCIPAL INVESTIGATOR: James C. Barnes (PR525)
Environmental Research & Technology, Inc.
429 Marrett Road, Lexington, Massachusetts 02173

DISCUSSION OF SIGNIFICANT RESULTS:

Sea ice is detectable in all of the ERTS MSS bands and can be distinguished from clouds through a number of interpretive keys. The photographic processing of prints from the original 70 mm negatives can be important for ice detection, however, since exposures selected to retain detail in land areas may result in the loss of significant ice features. Exposures that are not suitable for ice detection have been noticed in both the black and white and color products. Overall, the MSS-4 (0.5 to 0.6 μm) and MSS-5 (0.6 to 0.7 μm) bands appear to be better for mapping ice boundaries, whereas the MSS-7 (0.8 to 1.1 μm) band provides greater detail in the ice features. An initial examination of a limited sample of color composite data does not indicate any obvious significant advantages in the use of the color products for ice mapping.

Considerable information on ice type can be derived from the ERTS data. Ice types that appear to be identifiable include: ice floes of various categories, pack ice of various concentrations, ice belts, brash ice, rotten ice, fast ice, leads, fractures, cracks, puddles, thaw holes and flooded ice. Although larger icebergs can be seen, it is difficult to distinguish them from ice floes. Ice features as small as the "small floe" (20 to 100 m across) can be detected, and the sizes of features somewhat smaller than 100 m across can be measured from enlarged ERTS prints. Ice concentrations can be mapped, and the resulting concentrations are in good areement with the limited amount of correlative data available to date. Ice features can be identified over 24-hour periods enabling their movements to be measured; some large floes can even be recognized over intervals of as long as 20 days, enabling mean ice movements over longer periods to be determined.

The multispectral analysis of the ERTS MSS-7 bands provides much information on ice type and ice surface features that cannot be derived from a single spectral band. For example, thaw holes can often be distinguished from puddles because of their different appearances in the two bands. These surface features can be indicative of ice age. Furthermore, snow lines on glaciers can be reliably mapped through the joint use of the MSS-4 and MSS-7 data.

Late in the reporting period a sample of color composite data (MSS Bands 4, 5 and 7) was received. The 22 scenes comprise about two-thirds of the retrospective data request submitted more than three months ago. The areas covered and the dates of the composites, which had been selected from the black and white data acquired earlier in the study period, are given in Table 1.

TABLE 1

COLOR COMPOSITE DATA SAMPLE

Geographic Area	Date and Pass Number
Arctic Ocean - Northern Beaufort Sea	7 September - Pass 644, 1 Scene 14 September - Pass 742, 1 Scene
Beaufort Sea - Prince Patrick and Bank Islands	22 August - Pass 420, 3 Scenes 23 August - Pass 434, 2 Scenes 4 September - Pass 601, 3 Scenes
Hudson Bay	26 July - Pass 041, 1 Scene
East Coast of Greenland	3 September - Pass 583, 2 Scenes 25 September - Pass 890, 4 Scenes 7 October - Pass 1057, 3 Scenes 8 October - Pass 1071, 2 Scenes

2. Correlative Ice Data

Additional aerial survey sea-ice charts have recently been received from the Navy Fleet Weather Central - Ice Forecast Office and from the Canadian Ice Forecasting Central. The Navy charts are for the Greenland Sea on three dates in late September and early October and the eastern Beaufort Sea on one date in early October. The Canadian charts are for the Beaufort Sea on five dates between early August and early October, and for the Canadian Archipelago on three dates in late August and early September.

3. Results of Analyses

The analysis of ERTS data is continuing using the procedure described in the previous progress report. Scenes from additional passes crossing the eastern Beaufort Sea, Canadian Archipelago, and Greenland Sea have been mosaiced, and ice features mapped onto transparent overlays. The correlative ice charts were received too late for use during this reporting period; comparative analyses between the ice features mapped from the ERTS imagery and those depicted on the ice charts will be undertaken early in the next reporting period.

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- M'Clure Strait Area

Analyses are in progress for two passes crossing the M'Clure Strait area, including parts of Prince Patrick, Eglinton, and Melville Islands to the north and Banks Island to the south. One pass is for 29 July (Identifiers 1006-20060, -20062, and - 20065) and the other is for 4 September (Identifiers 1043 - 20120, - 20122, and - 20125). The ERTS data show that significant changes in the ice conditions in M'Clure Strait have occurred during the five-week period.

On 29 July, fast ice exists along the northern and northwest coasts of Banks Island. Shore leads are observed, however, particularly near the mouths of the rivers that empty into M'Clure Strait along the northern coast of the island. Much of M'Clure Strait is covered by fast ice, although at the western end of the strait numerous fractures and leads can be detected. The structure of the ice break-up process seems to be evident in this imagery; fractures extending through the ice between Eglinton Island and Banks Island open into leads farther west and eventually into larger open water areas. Also, considerable detail on the ice surface is evident in the MSS-7 data, including areas of lower reflectance near Eglinton Island that are presumably areas of bare ice.

Five weeks later, the entire ice sheet in M'Clure Strait has broken up. Open water exists along the coast of Banks Island, with no fast ice evident. In M'Clure Strait, the ice concentration is now mapped as very close pack (7/8 to less than 8/8). Some water is visible in most areas, and the ice appears to consist of floes surrounded by brash ice. West of Banks Island, however, the ice edge does not appear to have moved a great distance, being only slightly farther west than it was on 29 July.

- Color Composite Data

The color composite data sample has not been analyzed thoroughly, since these data were received late in the reporting period. The initial examination of the data indicates, however, that some of the prints have been processed using an exposure that is not suitable for displaying ice features. As was the case with some of the black and white products received earlier in the contract period, these prints have been exposed to retain the highly reflective snow-covered and glacier areas along the east coast of Greenland. At this exposure the less reflective ice features are completely lost.

In the color composite prints, land definition is improved somewhat due to the increased contrast between the "brown" land, the "white" snow and ice, and the "blue" water. In some scenes, clouds appear "whiter" than does the ice, which tends toward the "blue". Thus, color composites may be useful for distinguishing quickly between ice and cloud. In certain scenes, there is also indication that ice floes and areas of fast ice are "whiter" than the surrounding broken ice fields and brash ice. At this point in the study, however, no conclusive statements can be made about the color products; overall, the initial review of the limited sample does not indicate any obvious significant advantages to the use of the color composites for ice detection.

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A separate discussion of significant results and their relationship to practical applications on operational problems, including estimates of the cost benefits of any significant results, is attached to this progress report.

4. Ice Observer Training Course

In January, Mr. C. James Bowley of ERT attended the "Ice Observer Training Course," conducted by the Navy Fleet Weather Facility in Suitland, Maryland. The course, which is designed primarily for the observers who will be on board the aerial survey flights, is under the direction of LCDR William Dehn of the Ice Forecast Office. The source material has been very useful in the analysis of the ERTS data, and, furthermore, the course provided an opportunity for contact with the personnel who are directly involved in the operational ice observing program.

5. ERTS-1 Symposium

During this reporting period, a paper was prepared for presentation at the ERTS-1 Symposium, held at the Sheraton Motor Inn, 5 - 9 March. The paper, entitled "Use of ERTS Data for Mapping Arctic Sea Ice," describes the results obtained under the subject contract through mid-February. The Symposium also provided an opportunity for contact with other investigators working in similar disciplines and/or geographic areas, and with scientists who have been involved in various ice programs. The discussions concerning characteristics of various types of ice features have provided useful information for the interpretation of the ERTS data.

B. PLANS FOR NEXT REPORTING PERIOD

During the next reporting period, analysis of the black and white data products will be continued. Additional enlargements will be prepared for selected areas, and further experimentation with photographic processing techniques will be conducted. Using these reprocessed data, efforts will be continued to determine more precisely the scales of the identifiable ice features and to develop reliable keys for interpreting ice types and type of ice surface features.

In addition to the black and white data, the sample of color composite data will be analyzed to determine whether color products offer significant advantages for ice mapping. In discussions with Navy personnel at the Ice Observers Training Course, it was pointed out that color is an important factor in aerial ice observing for determining information such as the stage of melting or re-freezing of puddles and the age of the ice. Therefore, although the initial examination of the ERTS color composite scenes did not indicate any obvious advantages in the use of these data, further investigation will be conducted.

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Ice distributions mapped from the ERTS data will also be correlated with the ice conditions depicted on the aerial survey ice charts. It is realized, of course, that in most instances the aerial survey charts may not provide information at the scale of the features detectable at the ERTS resolution. The charts will be useful, however, for verifying the ice edge and concentration boundaries, and should provide information on ice age.

During the next reporting period, we anticipate that ERTS coverage of the Arctic will again be available, with the increasing illumination during the spring season. Data from the spring will be of considerable interest, since the Arctic ice cover reaches its maximum extent during this season.

C. PROBLEMS

No problems to impede the progress of the investigation are anticipated.

D. ERTS IMAGE DESCRIPTION FORMS

Image Descriptor Forms are attached to this progress report.

E. FUNDS

It is anticipated that the remaining funds will be adequate for successful completion of the investigation.

Very truly yours,

James C. Barnes

James C. Barnes
Principal Investigator

JCB:es.

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ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D
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ID

DATE 15 March 1973

PRINCIPAL INVESTIGATOR Mr. James C. Barnes

USER ID
~~GSFC~~ P525

ORGANIZATION Environmental Research & Technology, Inc.

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Ice Floes	Snow	Coast	
1003-18064 MP	X	X	X	Rivers, Stratocumulus
1024-18225 MP	X	X	X	Mountains, Fast Ice, Bays, Islands, Rivers, Stratocumulus
1030-18573 MP	X	X	X	Fast Ice, Ice Pack, Islands, Bays, Lakes, Stratocumulus
1030-18575 MP	X			Ice Pack, Islands, Lakes
1035-19425 MP	X	X		Ice Pack, Islands, Mountains, Bays
1035-19251 MP	X	X		Ice Pack, Islands, Mountains, Stratocumulus
1076-21392 MP	X			Cirrus, Stratocumulus, Ice Edge
1076-21394 MP		X		Ice, River, Coast, Bay, Stratocumulus
1079-13190 MP	X	X	X	Ice Pack, Island, Bays, Rivers
1079-13202 MP	X	X	X	Glacier, Mountains, Fiords, Moraines
1081-20243 MP	X			Cumulus
1081-20245 MP	X			Ice Edge, Cumulus
1087-20592 MP	X			Cumulus

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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