ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC.

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10 November 1972

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

Attention: Dr. Vincent V. Salomonson
ERTS-A Proposal No. SR201: Evaluate the Application of ERTS-A Data for Detecting and Mapping Snow Cover

Principal Investigator: James C. Barnes, PR011

Gentlemen:

This is the second 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 5-21803. This report covers the period from 31 August to 31 October 1972.

The purpose of this investigation is to evaluate the application of imagery from the ERTS-A RBV and MSS sensors for snow survey. The objectives are: to determine the spectral interval most suitable for snow detection and mapping; to determine the accuracy with which snow lines can be mapped in comparison with the accuracies attainable from other types of measurements; and to develop techniques to differentiate reliably between snow and clouds, to attain accurate geographic referencing, and to understand the effects of terrain and forest cover on snow detection. The results will demonstrate the advantages and limitations of spacecraft high-resolution, multispectral measurements for snow survey and will provide the analyst with interpretive techniques that will enable the maximum use of data from ERTS and future spacecraft systems.

A. ACCOMPLISHMENTS DURING REPORTING PERIOD

1. Data Collection

During this reporting period, data from 42 ERTS passes covering the western United States during the period from 26 July to 7 October 1972 were received. From the initial examination of the 70 mm positive transparencies it appears that only a limited amount of mountain snow exists in a few of these passes. For the appropriate frames, enlarged positive prints are currently being processed from the transparencies. As discussed later in the progress report, however, the processing of positive prints is a tedious

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task, because the corresponding 70 mm negatives are not suitable for reproduction using standard photographic equipment.

Because the initial period of operation of ERTS-1 has been during the season when little snow cover exists within the United States, the data catalogs and the GSFC browse facility have been reviewed to select data from geographic areas other than those originally defined. Based on this review, frames from several passes crossing Western Canada and the northwestern United States in which mountain snow can be detected have been requested. Additionally, a standing order request was submitted for three specific areas, two in Canada and one for the Cascades area of Washington. In subsequent discussions with the Technical Monitor, it was agreed to consider this as an anticipated data request rather than a standing order; the objective of the request will be to obtain selected frames from these additional areas until usable data over the originally defined areas is acquired during the winter season. A copy of the standing order form is attached.

An RBV color composite of one frame over a part of Washington (1006-18313-123, 29 July 1972), has also been received. This frame shows snow cover in the Olympic Mountains and a portion of the Cascades including Mt. Rainier. Several ERTS passes over the Arctic have also been received for use in a separate study (SR126: Evaluate the Application of ERTS-A Data for Detecting and Mapping Sea Ice). Snow cover is detectable in many of the frames from these passes.

2. Data Analysis

Initial examination of the positive transparencies to select frames to be printed has been conducted using the MSS-4 band (0.5 to 0.6 μm). At this spectral interval, snow has a significantly higher reflectance than does the surrounding snow-free terrain. Furthermore, even at the relatively small scale of the 70 mm transparencies, it appears that mountain snow can be differentiated from clouds principally because of the sharply defined snow boundaries, the lack of shadows that are particularly noticeable with cellular clouds, and the configuration of the patterns. In the one available color composite print, the apparent snow line has been mapped using an acetate overlay. The resulting patterns have been compared with contour charts derived from the National Topographic Map Series (Scale 1:250,000). Although the scale of these maps is larger than that of the 9.5 inch ERTS prints, the maps have nevertheless been found to be very useful.

3. Preliminary Results

The frames for which enlarged prints are currently being made show apparent snow cover in the Lewis Range in Western Montana, the Bitterroot Range along the Montana-Idaho border, the Salmon River Mountains in Idaho, the Sierras in California, and the Wallowa Mountains in Oregon. In the color-composite picture, snow is visible in the Olympic Mountains and the Cascades, in the Mt. Rainier area. The preliminary analysis of this frame indicates that in both areas the mean snow line is just above the 5000 ft level.

The ERTS data over the Arctic show the seasonal increase in snow cover in several areas. For example, in late July Banks Island in the Canadian Archipelago is completely snow-free (26 July, Identifier 1003-19504-123); in early September, however, snow covers the higher elevations of the central portion of the island, and in late September the entire island is snow-covered (4 September, Identifier 1043-20122-4567; 21 September, Identifier 1060-20063-4567). With snow cover, relatively small scale terrain features, such as isolated hills, stream valleys, gullies, and ridges, are greatly enhanced. This is particularly evident in the MSS-7 band (0.8 to 1.1 μm) where large differences in brightness exist between sunlit features and shadows in the low-sun angle imagery.

In other Arctic data, considerable detail is evident in glaciers located along the east and west coasts of Greenland (for example, 23 September, Identifier 1062-16504-4567). Detectable features include imbedded sediment trails (medial moraines), terminal moraines, crevassed areas, and apparent limits of new snow cover over older glacial ice. Furthermore, significant differences are apparent in the various spectral bands. Several glaciers exhibit a uniform reflectance in the MSS-4 band (0.5 to 0.6 μm), whereas in the MSS-7 band (0.8 to 1.1 μm) the lower elevation portions appear much darker than the higher elevation portions. This difference in reflectance is believed to be due to the existence of melt-water on the surface of the glacier at the lower elevations.

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

B. PLANS FOR NEXT REPORTING PERIOD

During the next reporting period, it is anticipated that the data ordered through the retrospective data request procedure will be received. Through review of the data catalogs and through the computer query and search capability, cloud-free imagery for the additional geographic areas in Washington and western Canada will also be requested. It is also expected, of course, that useful data from the originally defined areas, especially the Sierra Nevada and the Upper Columbia Basin, will soon be available with the approach of the winter season.

Snow extent will be mapped from the prints currently being processed at the ERT photographic laboratory and from the other data after they are received and processed. The analysis procedures will include determining the snow-line elevation in mountainous terrain and locating snow-cover boundaries in flat-terrain areas. Particular attention will be given to determining changes in snow-line elevation; since the initial data are from the season of minimum snow cover, the snow line should lower dramatically as the winter season approaches. The accuracy with which snow can be mapped from the ERTS data in comparison with other data sources will be measured, and techniques to improve the identification and mapping of snow extent using the various spectral bands will be investigated.

C. PROBLEMS

Although the original product order forms submitted with Proposal SR201 requested 70 mm negatives and 9.5 inch positive prints, it was agreed to accept 70 mm positive transparencies instead of the prints because of the load on the GSFC data facility. Examination of the negatives has revealed, however, that they are of extremely high-density quality and would require a high-intensity light source for production of prints. We understand that NASA has realized this problem and is currently formulating a list of suggestions to allow users a suitable reproduction with more conventional photographic equipment. In the meantime, prints are being prepared from the more usable 70 mm positive transparencies; the process is tedious, however, and results in the loss of a considerable amount of the data content.

Because of the time and effort required to process usable prints from the transparencies provided to date, we believe that this problem may impede the desired progress of the investigation. Early in the next reporting period, therefore, we plan to contact the Technical Monitor to discuss the situation. If negatives suitable for standard photographic processing cannot be made available, it is hoped that NASA will provide 9.5 inch positive prints for use in this study.

D. ERTS IMAGE DESCRIPTOR 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:jm
Enclosure

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ERTS 1 STANDING ORDER FORM
(See Instructions on Back)

DATE 19 September 72

GSFC ID NUMBER PR011

PRINCIPAL INVESTIGATOR James C. Barnes

TELEPHONE NO. 617 - 861 - 1490 ☐ NEW

SHIP TO: James C. Barnes
(NAME)
Environmental Res. and Tech., Inc.
(AGENCY)
429 Marrett Road
(STREET)
Lexington, Massachusetts 02173
(CITY) (STATE) (ZIP)

☒ ADDITION
☐ CHANGE
☐ DELETION

CATALOGS DESIRED
STANDARD ☐ U.S. ☐ NON-U.S.
DCS ☐
MICROFILM ☐ U.S. ☐ NON-U.S.
☐ CHECK IF ADDRESS IS NEW

NDPF USE ONLY
D ____
N ____
ID ____
DTM ____
TM ____
TM APP ____

AREA NUMBER	GEOGRAPHIC POINTS: LATITUDE	GEOGRAPHIC POINTS: LONGITUDE	CLOUD COVER %	QUALITY	COVERAGE PERIOD: START DATE	COVERAGE PERIOD: STOP DATE	PROD: TYPE	PROD: FORMAT	TICK MARK	QUANTITY	RBV BANDS 1	RBV BANDS 2	RBV BANDS 3	MSS BANDS 1	MSS BANDS 2	MSS BANDS 3	MSS BANDS 4	DELETE
	5000 N	12200 W	5	F	081872	063073		M		1				✓	✓	✓	✓	
	5000 N	11900 W						P		1				✓	✓	✓	✓	
	4600 N	12100 W																
	4600 N	12200 W																
	5300 N	12800 W	5	F	081872	020173		M		1				✓	✓	✓	✓	
	5300 N	12500 W						P		1				✓	✓	✓	✓	
	5000 N	12100 W																
	5000 N	12500 W																
	5300 N	12000 W	5	F	081872	020173		M		1				✓	✓	✓	✓	
	5300 N	11700 W						P		1				✓	✓	✓	✓	
	5000 N	11500 W																
	5000 N	11800 W																

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ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D
N
ID

DATE 10 November 1972

PRINCIPAL INVESTIGATOR Mr. James C. Barnes

USER ID GSFC P 011

ORGANIZATION Environmental Research & Technology, Inc.

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	SnowPack	Mountain	Rivers	
1006 18313 RP	X	X	X	Cities, Urban Areas Lumbering Areas, Bays, Lakes, Clearings (Power-lines), Highways, Valleys Coast, Forest, Islands, Agriculture
1037 18023 MP	X	X	X	Lakes, Orographic Cloud, Urban Area, Cities
1043 18372 MP	X	X	X	Fog
1020 18112 MP	X	X	X	Lakes, Agriculture, City, Urban Area
1020 18110 MP	X	X	X	Lakes, Orographic Cloud
1020 18092 MP	X	X	X	Orographic Cloud, Urban Areas, Lakes, Cities
1036 17565 MP	X	X	X	Lakes, Urban Areas, City, Agriculture
1036 17571 MP	X	X	X	Lakes, Urban Areas, City
1036 17574 MP	X	X	X	Orographic Clouds, City

*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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NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

DISCIPLINE: WATER RESOURCES, SNOW SURVEYS

TITLE: EVALUATE THE APPLICATION OF ERTS-A DATA FOR DETECTING AND MAPPING SNOW COVER (SR No. 201)

PRINCIPAL INVESTIGATOR: James C. Barnes (PR011)
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DISCUSSION OF SIGNIFICANT RESULTS:

Preliminary results of the analysis of a limited sample of ERTS-1 data from the western United States and the Arctic indicate that snow cover can be detected in the MSS-4 (0.5 to 0.6 μm) and MSS-5 (0.6 to 0.7 μm) bands by its high reflectance compared to that of the surrounding snow-free terrain. Snow can generally be distinguished from cloud because of well-defined boundaries as compared with the less distinct cloud edges, the lack of shadows characteristic of clouds, and pattern configurations that fit closely with higher elevations and terrain features. At higher latitudes where repetitive ERTS coverage occurs snow can also be identified by the day-to-day continuity of the patterns. In the longer wavelengths, particularly the MSS-7 (0.8 to 1.1 μm) band, the contrast between snow and snow-free terrain is much lower, and, thus, snow is more difficult to detect.

A comparison between snow patterns mapped from one RBV color composite (29 July, Identifier 1006-18313-123) and topographic charts indicates the snow-line elevation in the Olympic Mountains and a part of the Cascades in Washington to be just above the 5000 ft level. Snow has also been identified in the Lewis Range in Western Montana, the Bitterroot Range along the Montana-Idaho border, the Salmon River Mountains in Idaho, the Sierra Nevada in California, and the Wallowa Mountains in Oregon. These data are currently being analyzed.

ERTS data from the Canadian Arctic show the seasonal increase in snow cover in several areas. For example, on 26 July (Identifier 1003-19504-123), Banks Island in the Canadian Archipelago is completely snow-free; on 4 September (Identifier 1043-20122-4567) snow covers the higher elevations of the central portion of the island, and on 21 September (Identifier 1060-20063-4567) the entire island is snow-covered. With the snow cover, relatively small-scale terrain features, such as isolated hills, stream valleys, gullies, and ridges, appear greatly enhanced, particularly in the MSS-7 band (0.8 to 1.1 μm).

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