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January 7, 1983

NASA
Goddard Space Flight Center
Greenbelt, Maryland 20771

Attention: D. Kugelmann, Code 902.1
Technical Officer

Reference: Contract NAS5-27384

Dear Ms. Kugelmann:

Per the above referenced contract, enclosed are 13 copies of the First Quarterly Progress Report for the Study of Landsat-D Thematic Mapper Performance as Applied to Hydrocarbon Exploration for the period October 7, 1982 to January 7, 1983.

Sincerely,

John R. Everett
Principal Investigator

Enclosures

cc: Publications Section, Code 253.1

(E83-10235) STUDY OF LANDSAT-D THEMATIC MAPPER PERFORMANCE AS APPLIED TO HYDROCARBON EXPLORATION Quarterly Progress Report, 7 Oct. 1982 - 7 Jan. 1983 (Earth Satellite Corp.) 5 p HC A02/MF A01 CSCL 05B G3/43

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EARTH SATELLITE CORPORATION

FIRST QUARTERLY PROGRESS REPORT UNDER CONTRACT NAS5-27384

STUDY OF LANDSAT-D THEMATIC MAPPER PERFORMANCE
AS APPLIED TO HYDROCARBON EXPLORATION

Period Covered: October 7, 1982 to January 7, 1983

I. Data Received

Test tapes have been received for the Detroit, Michigan (0009-15413) and the Mississippi River, NE Arkansas (40037-16031) areas. Both these tapes were in the fully processed (P) format, with radiometric and geometric correction. In the case of the Detroit tape, only Thematic Mapper bands 1 through 4 were received, since the acquisition date of the scene preceded operation of the three longest wavelength Thematic Mapper channels.

No data has yet been received for the test sites of EarthSat's proposed investigation.

II. Processing and Interpretation

Since no data of our selected test sites has been available yet, EarthSat's activities during this reporting period have been confined to:

(1) Processing and enhancement of the two test scenes referred to above.

(2) Examination and evaluation of these scenes at scales up to 1:10,000, using both hardcopy output and interactive screen display. (Since the test scene areas are not of interest for the hydrocarbon exploration evaluation proposed in our experiment, the analysis to date has been general rather than discipline-specific.)

(3) Principal component analyses of selected subscene areas of the Arkansas scene.

III. Initial Evaluation

A. Detroit Scene

The Detroit scene at large scale shows evidence of an along-line data slip every sixteenth line in TM channel 2. Although hardcopy output composites of TM channels 1, 2, and 3 (natural color) at scales up to 1:100,000 do not make this data slip apparent, larger scale hardcopy outputs would reveal it. Very large scale (up to 1:10,000) products were therefore generated in false color using TM channels 1, 3, and 4. The subjective evaluation of these enhanced scenes by EarthSat staff indicate that the products are very acceptable for interpretation at scales up to 1:50,000, and will be useful for change mapping probably up to 1:24,000 scale. The significant striping visible in water bodies for both the natural color and false color products indicates that the detector calibration is probably performing below the preflight specification. A direct check of this using individual detector histogram comparisons is desirable. EarthSat will perform such an analysis if and when A or B format tapes (without geometric correction, and preferably without any radiometric correction) become available.

B. Arkansas Scene

No hardcopy outputs have as yet been generated for this scene. The following comments therefore apply to evaluation performed on the interactive color display.

For a set of 512 x 512 windows within the scene, variance-covariance matrices were computed and principal component analyses performed. The variance-covariance matrix and associated eigenvalues and eigenvectors for the window beginning at Row 513 and Column 513 are shown as Figures 1 and 2. Since this whole scene contains a substantial amount of haze and light cloud, the following observations may be conditioned by that fact. However, subject to that caution, initial analysis suggests the following:

(1) The new shortwave infrared channels (TM 5 and 6) are a highly significant new data source. In the principal eigenvector, accounting for 58% of total variance, TM 5 and TM 6 have the largest weights of any of the 7 bands. The second principal component is dominated completely by TM 4.

(2) The thermal channel (TM 7) shows negative correlation with TM 1 through 4. In our experience with MSS data, we have never encountered a variance-covariance matrix with negative elements. Their occurrence with TM data introduces the possibility that for some scenes the principal eigenvector may lie outside the positive hyperoctant. This may permit the development of a class of projection operators never encountered with MSS data. This question needs additional analysis.

ORIGINAL VARIANCE/CORRELATION MATRIX

	MEAN	1	2	3	4	5	6	7
1:	86.60	40.22	0.90	0.89	0.14	0.64	0.69	-0.36
2:	36.37	0.90	20.15	0.93	0.22	0.69	0.75	-0.20
3:	32.34	0.89	0.93	47.06	0.02	0.75	0.24	-0.09
4:	94.94	0.14	0.22	0.02	247.40	0.22	0.07	-0.14
5:	77.22	0.64	0.69	0.75	0.22	256.74	0.92	0.14
6:	27.43	0.69	0.75	0.84	0.07	0.92	93.80	0.15
7:	127.22	-0.36	-0.20	-0.09	-0.14	0.14	0.15	24.98

FIGURE 1

LIST OF EIGENVALUES AND EIGENVECTORS

NUMBER	% TOT VAR	V1	V2	V3	V4	V5	V6	V7
1	57.8692	0.2261	0.1730	0.2683	0.3072	0.7527	0.4311	0.0101
2	31.8596	-0.0722	-0.0319	-0.1495	0.9440	-0.1837	-0.2067	-0.0611
3	6.7602	0.5586	0.3169	0.4014	0.0032	-0.3519	-0.0450	-0.5483
4	2.1533	0.[illegible]330	0.2469	0.3960	0.0927	-0.4119	0.2583	0.7303
5	0.8492	-0.3076	-0.1756	-0.0853	0.0503	-0.3144	0.8059	-0.3412
6	0.3478	-0.7308	0.4024	0.4601	-0.0105	0.0843	-0.1992	-0.2130
7	0.1648	0.0110	0.7842	-0.6073	-0.0451	-0.0154	0.1160	0.0198

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FIGURE 2

(3) Examining color combinations of principal components on the display, it was observed that the (P_1, P_2, P_3) image[1/] and the (P_1, P_2, P_4) image exhibited more haze and a generally poorer definition than either the (P_1, P_2, P_5) or the (P_1, P_2, P_6) composite images. This is at first sight surprising, since whereas the third and fourth principal components account for 7% and 2% of the total variance respectively, the fifth and sixth principal components account for only 0.8% and 0.3% of the variance.

We believe that this result is caused by the large component of TM 7 (the thermal channel) present in both the third and fourth eigenvectors. Visual inspection reveals that the thermal channel is very sensitive to cloud and haze. In addition, although it has been resampled to 30 meter resolution, it is intrinsically of 120 meter resolution. Addition of a substantial contribution from the thermal channel may therefore lead to degraded resolution of resulting color composites. This is a question that will be explored in more detail during the second reporting period. It is interesting to note that all published algorithms for principal component analyses deal only with spectral properties, and presume that each channel is equally acceptable from the point of view of its spatial resolution. Although this was certainly true for MSS data, more analysis must be performed to determine the appropriate way of combining the 120 meter TM 7 data with the other, higher resolution channels.

IV. Proposed Analyses and Possible Problems

It is not yet clear whether NASA plans to make A or B format tapes available for TM data. If P tapes continue to be the main data source, we would propose to concentrate our efforts on multispectral analyses of the type initiated above, and on geologic interpretation of the resulting enhanced images. However, it should be noted that many of the statistical data tests we have proposed presume the availability of geometrically uncorrected tapes. Should these continue to be unavailable, we would propose that a work statement modification be made to permit us to carry through appropriate P tape analyses, and that activities involving A tape manipulations accordingly be eliminated.

1/ (P_i, P_j, P_k) indicates the color image obtained by color combining the ith, jth, and kth principal component images. P_1 is the band combination corresponding to the largest eigenvalue of the variance-covariance matrix, P_7 to the smallest.