General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

DOT

PERFORMANCE EVALUATION AND GEOLOGIC UTILITY OF
LANDSAT-4 TM AND MSS DATA

NAS 7-918

Earnest D. Paylor
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109

March, 1984
Third Quarterly Report
December-March, 1983-84

Prepared for
Goddard Space Flight Center
Greenbelt, Maryland 20771

(E84-10099) PERFORMANCE EVALUATION AND GEOLOGIC UTILITY OF LANDSAT-4 TM AND MSS DATA Quarterly Report, Dec. 1983 - Mar. 1984 (Jet Propulsion Lab.) 10 p HC A02/MF A01 CSCL 08G G3/43

N84-21918

Unclas 00099

INTRODUCTION

The primary objective of JPL's LIDQA study is to evaluate Landsat-4 TM and MSS data in the context of geologic applications. This entails quantitative analysis of the data, including assessment of both spatial and spectral characteristics.

As summarized in Table I, a number of TM data sets have been acquired for the study. Six SCROUNGE-processed, P-format scenes have been acquired and processed. A- and B-format data for one of these scenes have also been acquired and analyzed. Data from Landsat-D', was requested for the analysis. Preliminary results indicate that, compared with MSS data, TM data substantially increases the amount of information available for geologic applications.

ACCOMPLISHMENTS AND SIGNIFICANT RESULTS

Analysis during the fourth quarter of LIDQA was concerned with radiometric calibration accuracy of TM data, radiometric comparison of A-, B-, and P-format data, and geometric registration accuracy of the TM data at enlarged scales.

Radiometric analysis of the Wind River Basin, Wyoming, scene is near completion. The analysis demonstrates that the TM system can used to extract image reflectance spectra from ground targets following calibration of the system (i.e., calibration of image DN to percent ground reflectance by removing atmospheric and instrumental factors). The calibration procedure, developed in TM simulator studies and implemented on the TM data last quarter, consists of plotting recorded radiance (DN) values of identifiable ground targets against the target's field-measured reflectance values in each TM band. Seven calibration targets were selected so that most of the 0-to-100 percent reflectance range could be used in the analysis. Over 300 field reflectance measurements were collected for the analysis during the period of October 28 to November 3, 1983.

During this quarter, field spectra for each calibration target were averaged, and their range of reflectance values determined. The averaged spectra were digitally convolved with TM filter functions in order to reduce them to equivalent TM values. These convolved data were subsequently used to refine the calibration or regression lines determined last quarter. Figure 1 illustrates the refined calibration lines: regression parameters are summarized in Table II.

The calibration results not only allow conversion of TM data to spectral reflectance, but also yield parameters that constrain atmospheric models. With a specific model of the atmosphere, the calibration gain and offset terms may be used to obtain estimates of atmospheric scattering parameters and atmospheric optical depth. These estimates may be used in complete radiative transfer models to apply atmospheric corrections in a general way to image data. This aspect of the calibration, is currently under investigation.

The calibration gain parameter can be used to determine the sensitivity of the TM system. The just resolvable reflectance difference $\Delta_{\rho i}$ obtainable, determined by the quantization of the scanner radiance measured in the DN interval ΔDNi, is given by:

$$\Delta \rho i = \frac{d\,DNi}{d\,\rho i}\ \Delta DNi$$

where the slope (gain) of the calibration curve for the ith TM channel is the derivitive $\frac{d\,DNi}{d\rho i}$. Increase radiometric resolution is clearly obtained by increasing the slope of the calibration line, which in turn, is related to the dynamic range of the TM system (i.e., increasing the gain and offset of the TM system increases the dynamic range, and increases the radiometric resolution or sensitivity of the system).

A-, B-, and P-format data of the Wind River Basin, Wyoming, were also compared for radiometric differences. DN frequency distributions (histograms) of each band reveal that B-format data yield histograms with the most structure or frequency-variability. The structure appears as a high-frequency (wavelength of 4 to 8 DN) cycling, with an amplitude of approximately 30 to 40 percent of the total DN distribution at that interval. The origin of these variations is most likely differences in response of the detectors in the arrays. A-format data exhibit less histogram structure; band means and standard deviations are higher, by 1 DN, than those of the B-format data. Overall, P-format data have the "smoothest" histograms, and the means and standard deviations in each band are generally 2 DN lower than those of the A-format data. No significant radiometric degradation, from raw data (B-format) to radiometrically and geometrically correct data (P-format), is expressed by these minor differences in frequency distribution.

A- and B-format data calibration offers an additional means of comparison to P-format data. Identification of calibration targets is more difficult due to the 16-line, 45-50 pixel offset associated with forward and reverse scans by the TM sensor. In spite of this problem, only one (grass) of the seven targets used in calibrating P-format data could not be identified in the A- and B-format data. Regression parameters derived from six-point fits of these A- and B-format data are summarized in Table II, along with P-format, seven-point fit parameters. The similarity in A-, B-, and P-format regression parameters further supports the conclusion that no significant radiometric changes occur in the TM data as a result of radiometric and geometric corrections by SCROUNGE processing.

P-format data of Death Valley, California are presently being calibrated. Ground targets are being selected for the analysis and their DN values extracted from the data tapes. Spectral reflectance measurements have already been collected from three of these targets (basalt, salt, and limestone) with a Hand Held Ratioing Radiometer during the periods December 15-17, 1983, and February 22-23, 1984.

The geometric fidelity of TM data is excellent. The Wind River Basin data have been enlarged to a scale of 1:24000 with no major geometric distortions, or misregistration problems to 7 1/2' USGS topographic maps. Eight 512 x 512 subareas in the basin are being used to check the data quality at this scale. Results show that spatial and spectral detail of the data at this scale is sufficient for precise photogeological interpretations. The data are now being used as a base to coregister other remotely sensed data. Digital elevation data will be used to quantify the geometric registration accuracy in the selected subareas.

CONCLUSION

Analysis this quarter demonstrates that:

1). TM data can be used to extract image reflectance spectra following calibration of the TM system.

2). Image DN vs. ground reflectance calibration scatterplots yield parameters which can be used to constrain atmospheric models.

3). The radiometric sensitivity of the TM system can be measured with image DN vs. ground reflectance scatterplots.

4). No significant radiometric degradation occurs in the TM data as a result of radiometric and geometric corrections by SCROUNGE processing.

5). TM data can be enlarged to scales as large as 1:24000 with no major geometric distortions or misregistration problems to USGS topographic maps.

PLANS

Fifth quarter LIDQA analysis will concentrate on:

1). Completion of Death Valley, California TM data calibration, and its comparison to the Wind River Basin, Wyoming TM calibration. Atmospheric parameters derived from these calibration results will also be compared.

2). Measuring the MTF of the TM system using data from the Wind River Basin.

3). Registration of TM data to Digital Elevation Data in order to quantify the geometric registration accuracy of the TM data.

4). Continuing atmospheric and radiometric sensitivity studies of the TM data in the Wind River Basin, Wyoming.

PROGRAM MODIFICATIONS

Landsat 4 MSS data will not be evaluated in the LIDQA investigation. The reasons for this change are:

1. Unavailability of the data in major areas of study
2. Preliminary TM results are so good that we would like to devote more effort to its evaluation.

Fifth quarter LIDQA will be used to decide whether or not the TM's effective spatial resolution, frequency response, edge response, settling time and MFF can be correctly measured, in terms of either system performance or geological applications, with natural ground targets, since artificial target deployment - TM data acquisition was unsuccessful at Lost River.

RECOMMENDATIONS

None

FUND EXPENDED

December-February, 1983-1984 expenditures: $33,690.00

PAPERS AND PRESENTATIONS

Conel, J.E., Lang, H.R., and Paylor, E.D., 1984. Preliminary Atmospheric Calibration and Radiometric Sensitivity Studies on Satellite and Aircraft Scanner Data: Submitted to the Second Annual Scene Radiation and Atmosheric Effects Characterization (SRAEC) Fundamental Research Science Meeting, January, 1984.

Conel, J.E., Lang, H.R., Paylor, E.D., and Alley, R.E., 1983, Preliminary Spectral and Geologic Analysis of Landsat-4 Thematic Mapper Data, Wind River Basin Area, Wyoming: Submitted to IEEE Transactions on Geoscience and Remote Sensing, December, 1983.

ORIGINAL PAGE IS
OF POOR QUALITY

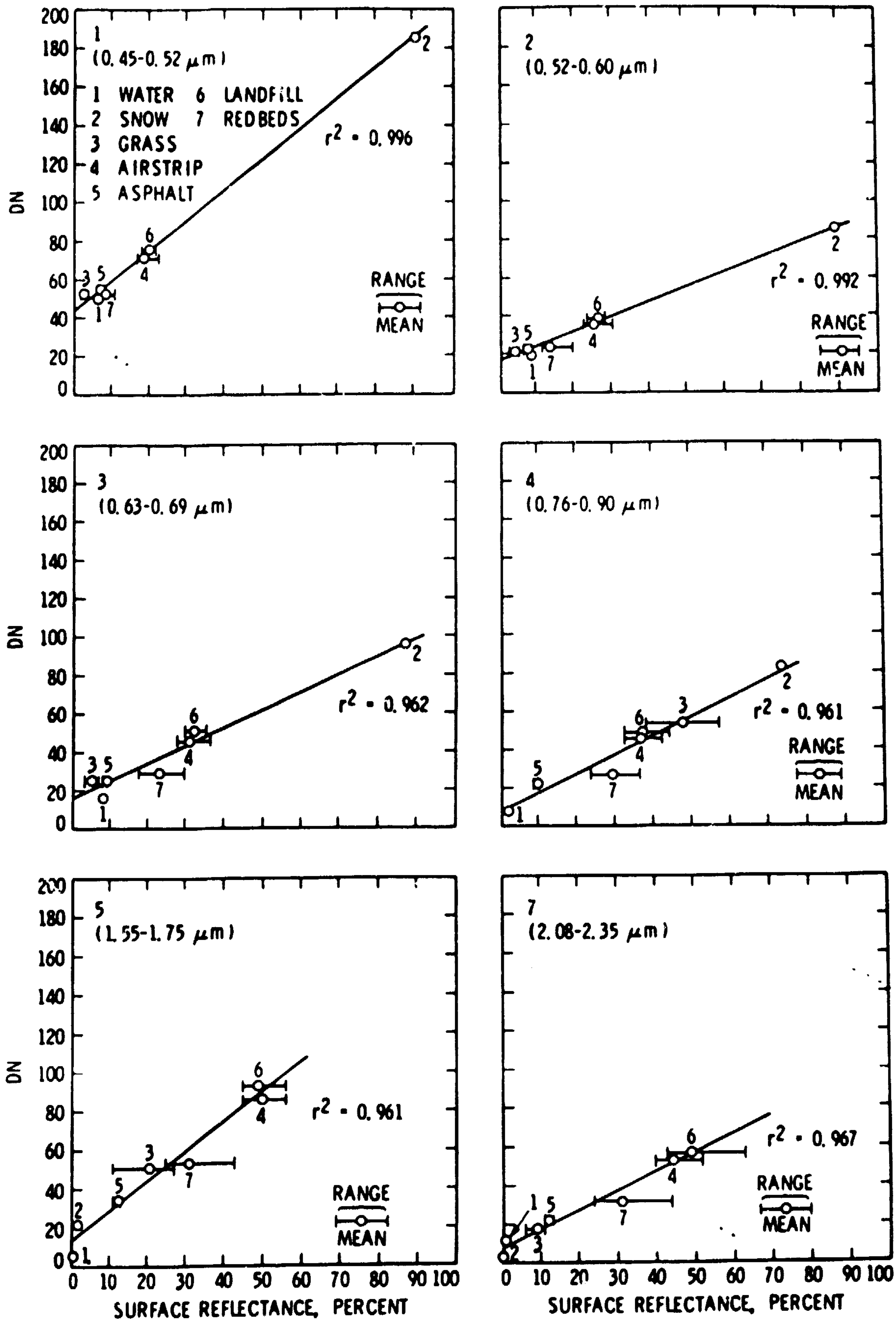

Figure 1

Table I. Landsat-4 TM scenes acquired for LIDQA investigations

Format	Location
Scrounge P-Tape	Death Valley, California Silver Bell, Arizona Owl Creek Mts., Wyoming Goldfield, Nevada Owens Valley, California Las Vegas - Lake Mead, Nevada
Scrounge A-Tape	Owl Creek Mts., Wyoming
Scrounge B-Tape	Owl Creek Mts., Wyoming

Table II. Comparison of B-, A-, and P-Format Calibration Parameters of TM Data in the Wind River Basin, Wyoming

Format	Band	Gain	Offset	R-squared
B	1	1.50	42.29	.999
	2	.71	14.13	.992
	3	.93	12.87	.996
	4	.92	7.81	.963
	5	1.42	13.48	.953
	7	.96	6.19	.960
A	1	1.52	41.46	.999
	2	.73	14.65	.991
	3	.94	16.63	.967
	4	.95	7.23	.957
	5	1.49	13.39	.958
	7	.99	6.05	.963
P	1	1.55	43.15	.996
	2	.77	15.83	.991
	3	.92	15.38	.961
	4	.999	7.15	.960
	5	1.53	13.15	.961
	7	.99	7.57	.966