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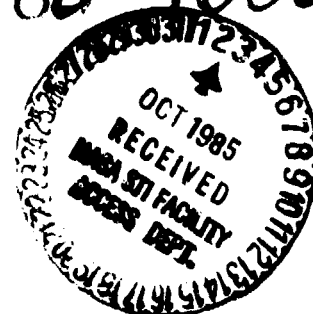
EXECUTIVE SUMMARY

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LANDSAT-4 TM IMAGE DATA QUALITY ANALYSIS FOR ENERGY-RELATED APPLICATIONS

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for

Key Words: Landsat-4, Thematic Mapper, Digital Image Processing, Thermal Band Radiometric and Geometric Analyses. Energy Research and Development Applications

Objective/Scope: The objective of this investigation is to evaluate Landsat-4 Thematic Mapper (TM) data performance and utility characteristics from an energy research and technology perspective. The program focuses on evaluating applicational implications of using such data, in combination with other digital data, for current and future energy research and technology activities. Prime interest is in using TM data for siting, developing and operating federal energy facilities. Secondary interests involve the use of such data for resource exploration, environmental monitoring and basic scientific initiatives such as in support of the Continental Scientific Drilling Program.

Approach: The basic approach is to utilize digital remote sensing/image processing and data integration techniques developed at the U.S. Department of Energy's Pacific Northwest Laboratory for processing, analyzing and evaluating Landsat-4 Thematic Mapper data. Data analysis and evaluation emphasis is on Landsat-4 TM data use in studies of the Columbia Plateau region in eastern Washington in general and the Hanford site in specific. However, Landsat TM data for other representative energy research and production sites are being analyzed and evaluated as well. Table 1 identifies the main image data quality characterization areas of investigation and the prime application areas of interest.

Data Status: To date, no Landsat-4 TM data have been received for our prime study site in the Columbia Plateau region of eastern Washington state. Excellent data were acquired for the Hanford site during the TDRS test on August 12, 1983, but CCTs have not as yet been received. Table 2 summarizes Landsat-4 TM data available to date and ancillary data sets being utilized.

Accomplishments/Preliminary Results:

1. Development of TM Image Analysis Programs. In anticipation of the 7-band Landsat-4 TM data, two special programs were developed for simultaneously using a vector scope and a color raster display. The first (Figure 1) is both a multiband or multisource program that provides for rapid, interactive enhancement and generation of multiband color composites containing the optimum combination of TM bands to highlight features of

prime interest. The second program (Figure 2) emphasizes quantitative single-band analysis for determining the digital counts (radiometric values) associated with a specific pixel (so called pixel-level) or as an integrated (multipixel-level) value for larger features or areas of interest.

2. **TMS Data Analysis.** Prior to the receipt of Landsat-4 TM data, NASA ERL provided PNL with Thematic Mapper Simulator (TMS) data for a nuclear power plant (Virginia Electric Power Company-North Anna Plant) to test the previously developed image processing algorithms. Principal component analyses of this data set clearly indicated that thermal plumes in surface waters used for reactor cooling would be discernible on Landsat-4 TM data.

3. **TM Data Analysis.** Because of TM data availability constraints to date, data quality and utility analysis efforts have been limited to the analysis and evaluation of TM day and night imagery acquired for DOE's Savannah River Laboratory in Aiken, S.C. on August 28, 1982 and December 24, 1982, respectively. Moreover, because of the uniqueness of the thermal band data, major emphasis was given to analyzing this band.

    The results of analysis efforts to date are described and graphically demonstrated in the two publications cited below. Basically, qualitative efforts indicate that the geometric and radiometric characteristics of the TM (CCT-PT) data are adequate to support most of our requirements for generating specialized enhancements, multiband composites and data integration (multisource) products. Quantitative findings, associated with TM thermal band analyses, although very preliminary indicate several potentialities for providing quantitative thermal data of the type required for basic research, modeling and energy facility monitoring functions. However, much more information and user experience are required relating to limitations imposed by calibration, data processing, atmospheric and sub-pixel or mixed-pixel effects.

Publications:

- Wukelic, G. E., and H. P. Foote, Landsat-4 Image Data Quality for Energy-Related Applications - Preliminary Results. Digest, Volume 1, 1983 International Geoscience and Remote Sensing Symposium, August-September 1983. (PNL-SA-11438)

- Wukelic, G. E., H. P. Foote and M. M. Pendergast, Monitoring Nuclear Facilities Using Landsat-4 Thematic Mapper Data, Proceedings of 1983 National Conference on Resource Management Applications: Energy and Environment, August 1983. (PNL-SA-11459)

Acknowledgements:

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TABLE 1. LANDSAT-4 Image Data Quality and Utility Characterization (Thematic Mapper Only)

DATA QUALITY

Radiometry	Spectral Information	Detector Replacement Algorithms		
		Band Compression Algorithms		
	Radiometric Information	Internal Calibration Algorithms	Channel to Channel	
			Band to Band	
		Scene Histogram Calibration Algorithms (Radiometric Destriping)		
		Absolute Scene Radiance Calibration Algorithms	Reflective Band	
			Thermal Band	●
		Noise Correction Algorithms		
Geometry	Geometry of Pixel	Ground IFOV		●
	Geometry of Image (Pixel Location)	Systematic Correction	Scan Profile	
			Detector Location	
			Between Scan Alignment	
			Ephemeris	
			Attitude	
		Geodetic Correction with GCPs	Reference Library Build	
			Scene to Reference Registration	●
		Resampling		

DATA UTILITY

Renewable Resources	Agriculture		
	Soils		
	Forests		●
	Range		
	Irrigation		●
Non-Renewable Resources	Geology/ Geoscience		●
	Image Science		●
	Other		
Planning/ Environmental Management	Regional/Urban Land Use		●
	Coastal Zone		
	Hydrology		
	Wildlife Habitat		
	Oceans		
	Facility Siting/ Monitoring		●

TABLE 2. Landsat-4 and Ancillary Data Status

	PATH/ROW	DATE	COMMENTS
1. LANDSAT-4 TM DATA			
PRIME STUDY SITE			
HANFORD SITE RICHLAND, WA	DAY 44/28 NIGHT 137/16	8/12/83	ACQUIRED DURING TDRS TEST CCT'S NOT AVAILABLE TO DATE
SECONDARY STUDY SITES			
SAVANNAH RIVER PLANT (SRP) SOUTH CAROLINA	DAY 17/37 NIGHT 116/207	8/28/82 12/24/82	RECEIVED 1/31/83 RECEIVED 3/28/83
PORTSMOUTH OHIO FACILITY	DAY 19/33 NIGHT 118/211	9/11/82	RECEIVED 6/83
WEST VALLEY, NY (BUFFALO, NY SCENE)	NIGHT 112/214	8/28/82	RECEIVED 11/16/82
2. TM SIMULATOR (TMS) DATA			
NORTH ANNA NUCLEAR POWER PLANT	DAY	9/11/81	RECEIVED 4/82 FROM NASA ERL

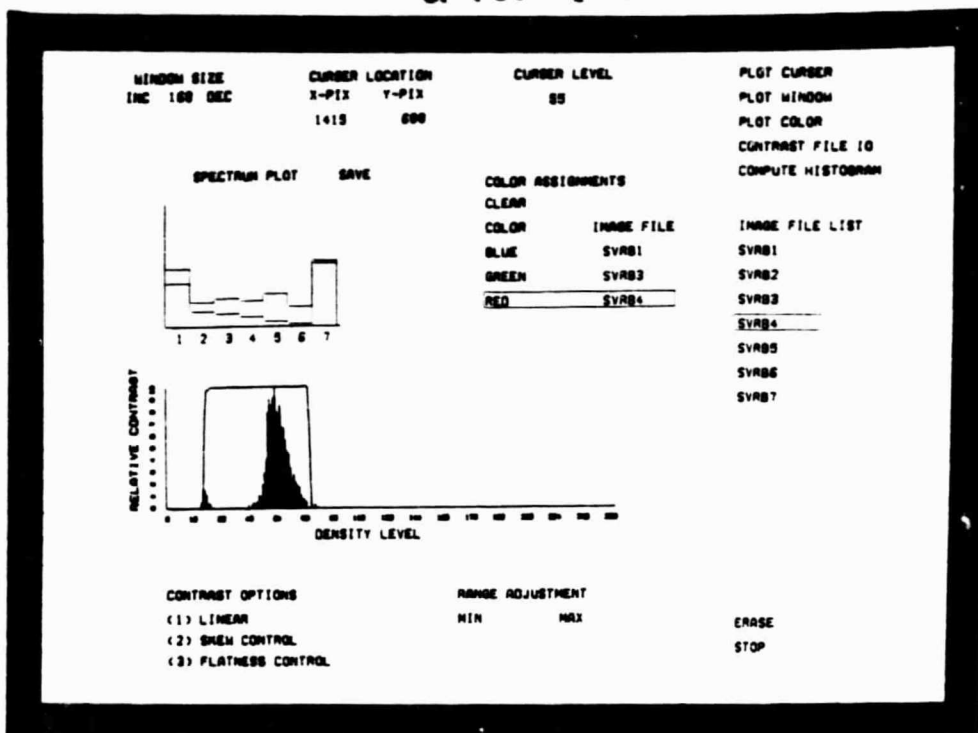*ALL DATA UTILIZED TO DATE : CCT-P DATA

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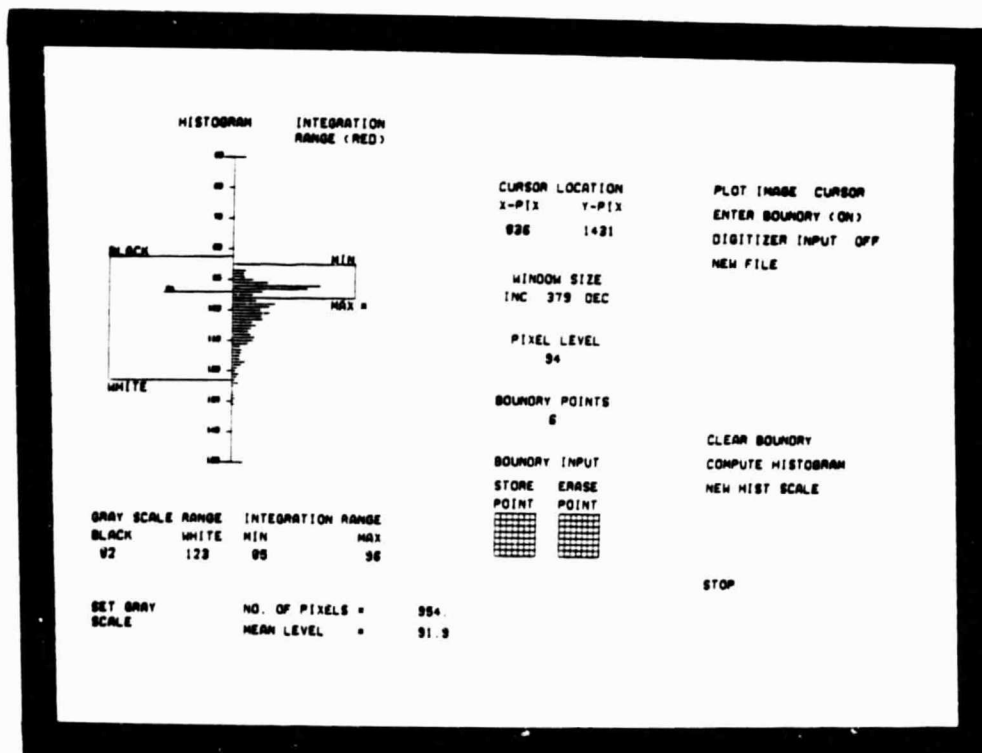Figure 1. PNL Interactive Computer Program for Qualitative
Landsat TM Analysis

Figure 2. PNL Interactive Computer Program for Quantitative
Landsat TM Radiometric Analysis