Task Assignment 132
October 1984

CHARACTERIZING THE SCIENTIFIC POTENTIAL OF SATELLITE SENSORS

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SAR Task Leader - Dr. Y. Lee

Task Objective:

The objective of this task is to provide analytical and programming support to characterize the potential of the Landsat Thematic Mapper (TM) digital imagery for scientific investigations in the earth sciences and in terrestrial physics. Secondary objectives of this task include providing technical support to define lower atmospheric and terrestrial surface experiments for the space station and providing technical support to the Research Optical Sensor (ROS) study scientist for advanced studies in remote sensing.

Work Performed:

The following work was performed in the areas indicated.

100 TM Radiometric Calibration

110 Coherent Noise

Algorithms and software for removing coherent noise from TM imagery are being developed on the Landsat Assessment System (LAS). The current method of correction is made on a line-by-line basis within the spatial domain as follows:

1. The Fast Fourier transformation (FFT) is calculated for each line of background data.
2. The mean and standard deviation (SD) are calculated for each background FFT spectrum.
3. A threshold value is set as Thresh = Mean + 3 * SD.
4. Any peak in the FFT spectrum that is above the threshold value is defined as being due to coherent noise.
5. Amplitude, phase, and frequency are calculated for each corresponding peak.
6. A noise image is created by using the phases, frequencies, and amplitudes of the noise peaks.
7. The noise image is subtracted from the original image to obtain an image with coherent noise removed.

A preliminary test of the algorithm will be performed within the background region of San Francisco scene 40392-18152. SAR plans to develop a new correction procedure for coherent noise that will resequence the TM data into the time

sampling domain, calculate the FFT on the resequenced data, extract the noise peaks, calculate the appropriate filter function, multiply the filter times the FFT data, calculate the inverse FFT, and resequence the resulting data back into the spatial domain.

120 Scan-Correlated Shift (SCS)

The following conclusions were made by SAR personnel and the ATR by examining SCS corrections of subimages of the San Francisco scene:

1. SCS correction of bands within the primary focal plane of the TM instrument is complicated by the concurrence of bright-target saturation (BTS) effects.

2. The background information of channels 4, 8, 10, and 12 of band 1 shows a significant scan-correlated shift greater than one digital count, which is easily detectable by the thresholding method reported earlier, even when mixed with BTS effects.

3. Bands 5 and 7 have no BTS effects.

4. Bands 2, 3, and 4 have a less significant SCS effect and a stronger BTS effect. BTS should be removed before making a SCS correction, otherwise, the correction determined by the thresholding method depends critically on the threshold value.

The SCS correction has been performed on bands 1, 5, and 7 of the San Francisco scene. The correction parameters, the binary masks, and the shift amplitudes were calculated by the characterization program, SCAN.EXE. Because the shifts are sub-DN for most channels, the difference between raw and calibrated images is not noticeable unless the images are contrast enhanced.

130 Bright-Target Saturation (BTS)

The BTS effect was modeled as an addition of two sensor response recovery effects. One effect is due to an increase in gain sensitivity and the other is due to a decrease in sensitivity of detector materials after the bright target is encountered. Once these effects are modeled, a least squares fit is done to the data of amplitude versus distance for each detector in bands 1 through 4. The least squares model for amplitude change, y(x), is

$$y(x) = -C1*EXP(-x/C2) + C3*EXP(-x/C4) \quad (1)$$

where x is the distance from the bright target boundary. The coefficients C1, C2, C3, and C4 are given in Tables 1 through 4, respectively.

A correction for BTS effects was performed on the San Francisco scene that has a large body of clouds along the left side of the scene. The BTS correction procedure developed by SAR proceeds by first finding the cloud boundary within a line.

Each scan line is searched from the left for 50 consecutive pixels with a gray value above 200. The boundary location is set to the first pixel of this string of consecutive pixels. The distance of every pixel within the line from the bright target is determined. Once the distance is determined, the amplitude change is calculated using equation 1 for the respective channel and subtracted from the raw image value. An examination of the results indicated that the preliminary test did not perform as well as expected. Task personnel feel that the regression procedure is not adequate at this time for such a detailed correction. Therefore, in a second attempt at correction, SAR only used the coefficients in equation 1, obtained from band 2, channel 12, to correct all channels in bands 1, 2, 3, and 4. Examination of the results revealed the band 2 correction had a confidence level of 95 percent, and bands 3 and 4 had confidence levels of 90 percent and 50 percent, respectively.

200 Image Analysis

210 Image Processing on VAX/LAS

The following 512 pixel x 512 line subscenes were selected from the B-tape of the San Francisco scene:

File Name	Starting Pixel	Starting Line
SF1.B1-B7	1451	865
SF2.B1-B7	1501	1377
SF3.B1-B7	2001	1985
SF4.B1-B7	2101	2337
SF5.B1-B7	2951	2753

BTS effects are apparent in all images except the first subscene. Calibrated images were produced as a preliminary test of SCS and BTS correction software. Figure 1 shows an example of an image before and after BTS correction.

A package of LAS programs was developed and used in a presentation to key NASA personnel on Oct. 25 and 29 to demonstrate the results from the TM radiometric characterization and calibration work. The package manipulates the following six sets of images:

1) subsampled, full-scene images of San Francisco from a TM P-tape

2) subscene images from the top of the San Francisco scene that do not have BTS

3) subscene images from the middle of the San Francisco scene that have BTS effects

4) TM B-Tape images of the same area as in set 3

5) BTS correction images of set 4

6) line profiles of forward and reverse scans before and after BTS correction

220 Image Processing on HP-3000/IDIMS

One-cycle and eight-cycle pseudocolor pixel prints were generated for seven TM bands of White Sands, NM.

The command file that generates one cycle pseudocolor pixel prints was modified to make black-and-white prints with the same annotation. The command file applies an equal area stretch to the image.

Eighteen black-and-white Polaroid prints were genenerated of the San Francisco TM scene to show the data before and after bright target saturation correction, scan correlated shift correction, and histogram equalization.

230 Ground Data Processing

A dump was made of the digital ground information files using the Geographic Entry System (GES) to get out the area of each polygon.

300 Production Support

Forty-five BRU and BURST tapes received from SBRC consist of 21 sets, (two tapes for each set) of Integrating Sphere (IS) test data and one set (of three tapes) of Internal Calibration (IC) test data. Four data files, including a four-window, 30-second general purpose collect (GPC) BRU, a five-window, 30-second GPC BRU, one forward scan BURST and one reverse scan BURST, were created for each IS test set. The data formats for these new GPC BRUs are different than the previous BRUs and are listed in Table 2. The file structure for these new tapes are also different than the previous tapes received from GE/VF. Previously, only one data file was put on each tape. A JCL to perform tape scan on the IBM 3081 has been modified to process multidata file tapes. Multidata files, either one, two, three, or up to four files, were found on these new tapes. This is inconsistent with the label on each tape that says two files were put on the tape. The first and third files on tapes that have 3075 or 3890 blocks are the 30-second GPC BRUs. The second and the fourth files on tapes that have ~ 1800 blocks are the BURSTs. Further identifications of each file is in processing.

400 Software Development

A new task member was introduced to the task and will work closely with project personnel on the improvement of the TRAPP program. SAR personnel met twice with the ATR to discuss the TRAPP current reporting capabilities and possible improvements. A task members modified the TRAPP program to add the "CAL ONLY" option and "VIDEO ONLY" option to process "TEMP CALL1 4-Window" and "TEMPCALL2 4-Window" data.

500 MSS Coherent Noise Analysis

Two unity RLUT (B-tapes) Landsat-4 and -5 scenes (March 31, 1984, and April 24, 1984) were entered into the Interactive Digital Image Manipulation System (IDIMS). Both scenes were found to contain bad data for coherent noise analysis. Most of the

data were found to be saturated in all bands. Furthermore, for areas that were not saturated, the features in the images did not correspond to the same features on the A-tape data. A Polaroid print was made of each image and delivered to the NASA scientist to document the problem.

To eliminate the problem of empty radiance bins in the Landsat A-tape data, SAR performed the following procedure:

- Histogram gain and offset radiometric calibration parameters were extracted for scan line of the image.
- Decompression look-up tables (LUTs) for Landsat-4 and -5 were copied from a NASA technical memorandum to obtain the raw gray values.
- The gain and offset calibration parameters were applied to every decompressed gray value to determine the radiometrically calibrated gray values for each image channel.
- The calibrated gray values were rounded to obtain the byte data equivalent.
- A look-up table was created that related the calibrated byte values back to the raw gray values.
- Separate histograms were generated for each line of image data for Landsat-4 and -5
- The calibrated to raw look-up table was checked for consistency and modified if a calibrated gray value that occurred in the image was not transformed back to a raw gray value. The table was checked to assure that each calibrated value was transformed to a raw value.

The above procedure was applied to each of the 24 detectors on each instrument. A batch job was set up on IDIMS to transform the calibrated gray values back to raw gray values and to generate Fourier transform plots of the coherent noise amplitudes.

Signficant Accomplishments:

Task personnel developed algorithms and software for the correction of coherent noise, Scan Correlated Shift, and bright target saturation effects. The software was successfully tested and the results presented to the ATR. As a result, SAR put together a package of programs on the LAS for demonstrating the results from characterizing and correcting TM radiometry. This package was demonstrated to key personnel from NASA/Goddard Space Flight Center and Headquarters.

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Problem Areas:

None.

Schedule Conformance:

Work is proceeding as planned.

Work Planned for Next Month:

100 TM Radiometric Calibration

Task personnel will continue revising correction algorithms for coherent noise, SCS, and BTS effects.

200 Image Processing

Task personnel will develop a set of images of before and after correction data for presentations and publications.

300 Production Support

SAR personnel will identify BRU and BURST data for the new SBRC tapes They will also copy and merge six data files onto one tape (approximately 16 tapes will be generated) and plot whole scan line for each BURST data file.

400 Software Development

Task members will continue to make improvements on the TRAPP program.

Deliverables Submitted:

Graphics:	10 black-and-white negative films of raw and calibrated TM images
Originator:	Y. P. Lee
Demonstration:	A demonstration package of task results on the Landsat Assessment System
Originator:	Y. P. Lee
Graphics:	14 Polaroid prints of one and eight cycle pseudocolored TM bands for White Sands, NM
Originator:	W. Hallada
Graphics:	18 black-and-white Polaroid prints of various TM bands before and after various radiometric corrections
Originators:	W. Hallada and Y. P. Lee

Graphics:	48 plots of the Fourier-transformed amplitudes for Landsat-4 and -5 MSS channels for a sample of 512 samples before radiometric correction
Originator:	W. Hallada
Graphics:	Polaroid prints of Landsat-4 and -5 MSS data to show saturated pixels
Originator:	W. Hallada

Computer Utilization:

The estimated computer time used this month is as follows:

Minutes	Computer
1855 (wall clock)	HP-3000 (IDIMS)
500 (wall clock)	HP-3000 (ERRSAC)

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Table 1

Bright Target Saturation, Band 1

Channel	C1	C2	C3	C4	
1	0.78	0.18	12222	12222	
2	2.38	0.98	3022	6222	*
3	2.78	1.98	2022	3222	
4	1.58	0.38	1022	9222	*
5	2.18	1.18	2822	3222	
6	2.38	2.18	3022	8222	
7	2.58	2.18	2222	8222	
8	2.10	-0.38	12222	12222	
9	1.38	0.58	3022	12222	*
10	2.10	-0.38	12222	12222	
11	2.10	-1.58	12222	4022	
12	0.22	-0.38	12222	12222	
13	1.78	0.58	2022	12222	*
14	2.78	2.58	2822	8222	
15	2.38	0.38	2022	12222	*
16	0.62	0.22	12222	10222	
AVG**	1.90	0.58	2222	8222	

** AVG over channels with mark *

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Table 2

Bright Target Saturation, Band 2

Channel	C1	C2	C3	C4
1	4.02	0.22	622	12222
2	4.69	1.49	911	5111
3	3.42	0.62	978	7778
4	2.78	0.38	978	8778
5	3.42	0.62	978	7778
6	4.62	0.62	622	12222
7	3.29	0.69	911	11111
8	4.49	1.09	911	5111
9	3.38	0.38	1022	10222
10	3.49	0.49	911	11111
11	3.29	0.69	911	11111
12	4.02	0.42	978	7778
13	4.22	0.62	978	7778
14	4.02	1.82	978	7778
15	3.38	0.38	1022	8222
16	4.69	0.89	911	7111
AVG	3.83	0.71	914	8824

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Table 3

Bright Target Saturation, Band 3

Channel	C1	C2	C3	C4
1	2.77	0.38	978	6778
2	3.02	0.22	822	12222
3	3.02	0.42	978	5778
4	3.22	0.62	978	5778
5	3.38	0.38	1022	8222
6	3.11	0.11	911	12111
7	2.78	0.38	1022	10222
8	4.69	1.29	911	5911
9	4.82	1.82	978	7778
10	4.11	-0.29	911	10111
11	3.58	1.58	1022	10222
12	4.82	0.62	722	12222
13	2.98	0.58	1222	12222
14	3.77	0.57	978	8778
15	4.18	1.58	1022	4222
16	4.98	1.78	1222	6222
AVG	3.70	0.75	981	8675

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Table 4

Bright Target Saturation, Band 4

Channel	C1	C2	C3	C4
1	2.42	1.62	1222	10222
2	3.02	1.62	978	6778
3	2.38	0.58	1022	8222
4	2.69	1.29	911	7111
5	2.69	0.89	911	9111
6	2.58	0.78	1022	6222
7	2.29	1.29	911	11111
8	3.22	1.62	978	6778
9	2.89	1.29	911	8111
10	1.98	0.98	1022	10222
11	2.69	1.69	911	7111
12	2.29	1.29	911	11111
13	3.38	2.98	1222	5222
14	2.89	1.49	911	6111
15	2.49	1.69	911	8111
16	2.09	1.29	911	11111
AVG	2.62	1.34	979	7542

Table 5

	Old 5-Window	Old 6-Window	Old 8-Window	New 4-Window	New 5-Window
Time Code	X	X	X	X	X
Start of Scan			X		X
Mid of Scan	X	X	X		X
End of Scan			X		X
Line End Code	X	X	X	X	
Shutter 1	X	X	X	X	
Shutter 2		X	X		
Cal Pulse	X	X	X	X	
Observation Transition					X
Size (blocks)	2890			3075	3075

*New BURST data files have size ~1800 blocks

Correcting Landsat-4 Thematic Mapper (TM/PF) Bright Target Radiometry in Band 2

(512 × 512 Unresampled Subscene of 40392-18152)

San Francisco Bay
Before Correction

San Francisco Bay
After Correction

J. BARKER/Y. LEE NASA/OCT 84

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Figure 1