SNF NS001-TMS CANOPY REFLECTANCE 1983-84

Summary:

The NS001 Thematic Mapper Simulator (TMS) was flown on the NASA C-130 aircraft over the Superior National Forest study area. TMS data were collected and processed for three days: July 13 and August 6, 1983; and June 28, 1984. The TMS was a scanning radiometer with eight wavelength bands. Band 8 was a thermal band and not processed in this study. The C-130 flew a "crisscross" pattern over the SNF, which provided a variety of sun and view angles. The TMS data were processed to provide reflectance values of study sites. These data are useful in the analysis of the bi-directional reflectance function of forest canopies.

The TMS radiance values were converted to reflectance using values for insolation, atmospheric transmittance, and path scattered radiance for the appropriate solar and view angles. No measurement of these values were made, so the LOWTRAN6 atmosphere model was used to generate them. Scattering contributions calculated from the path between the canopy and the sensor were subtracted from the sensor detected radiances and divided by the incident flux to generate reflectance factors.

Corrected canopy reflectance values for three days are included in the data set. Standard spherical polar coordinates, with zero degree azimuth due north, are given. Errors in the determination of these angles are possible due to the lack of precise aircraft position. The sensor zenith angles were determined from the sensor scan angle and should be accurate to within a degree. The sensor azimuth angles were determined from plotting the center points of a nadir view camera on an air photo of the area and connecting them to determine the aircraft heading. Because of the errors in this method, view azimuth accuracy is probably no more than two to three degrees. Solar zenith and azimuth were determined computationally from the time at the beginning of each flight line and should be within a degree. Sites referred to as 0 and 99 in the tables are observations of water.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

SNF NS001-TMS Canopy Reflectance 1983-84.

Data Set Introduction:

The NS001 Thematic Mapper Simulator (TMS) was flown on the NASA C-130 aircraft over the Superior National Forest study area. TMS data were collected and processed for three days: July 13 and August 6, 1983; and June 28, 1984. The TMS was a scanning radiometer with eight wavelength bands. Band 8 was a thermal band and not processed in this study. The C-130 flew a "crisscross" pattern over the SNF, which provided a variety of sun and view angles. The TMS data were processed to provide reflectance values of study sites. These data are useful in the analysis of the bi-directional reflectance function of forest canopies.

Objective/Purpose:

The TMS data were processed to provide reflectance values of study sites. These data are useful in the analysis of the bi-directional reflectance function of forest canopies.

Summary of Parameters:

Radiance, reflectance.

Discussion:

The NS001 Thematic Mapper Simulator (TMS) was flown on the NASA C-130 aircraft over the Superior National Forest study area. The TMS was a scanning radiometer with eight wavelength bands. Band 8 was a thermal band and not processed in this study. The C-130 flew a "crisscross" pattern over the SNF, which provided a variety of sun and view angles. The TMS data were processed to provide reflectance values of study sites. These data are useful in the analysis of the bi-directional reflectance function of forest canopies. TMS data were collected and processed for three days: July 13 and August 6, 1983; and June 28, 1984.

Data Processing

Several processing steps were required to turn raw TMS data into physically meaningful numbers for the test sites.

The TMS scanner sweeps through view angles of plus or minus 50 degrees. This introduces both geometric distortions and varying atmospheric path lengths across the scan line. At extreme scan angles, a pixel covers an area on the ground several times larger than at nadir. At the nominal 5000 foot altitude flown, a nadir pixel covers 3.81 meters along the scan, expanding to 9.22 meters at 50 degrees off nadir. To compensate for this distortion, the data were linearly resampled to a constant pixel size, the same size as the nadir pixel. The scan angle corrected images from different flight lines were then registered to a common image. The registration algorithm used control points to remove distortions locally rather than globally, and was effective in correcting for perturbations introduced by variations in aircraft motion. Sites were located in the imagery using photographs, descriptions of site locations, first hand knowledge and maps. Digital count values for areas four by four pixels, approximately 16 by 16 meters, were extracted from each flight line. Using the calibration data provided for each scan line, these values were converted to radiance values by subtracting the low blackbody radiance count and multiplying by the radiance calibration factor.

The TMS radiance values were converted to reflectance using values for insolation, atmospheric transmittance, and path scattered radiance for the appropriate solar and view angles. No measurement of these values were made, so the LOWTRAN6 atmosphere model was used to generate them. Scattering contributions calculated from the path between the canopy and the sensor were subtracted from the sensor detected radiances and divided by the incident flux to generate reflectance factors.

Results

Corrected canopy reflectance values for three days are included in the data set. The sun and view angles are referenced to the same coordinate system centered on the observation point. Standard spherical polar coordinates, with zero degree azimuth due north, are given. Note that the sensor and the sun are in line when they have the same coordinates. Errors in the determination of these angles are possible due to the lack of precise aircraft position. The sensor zenith angles were determined from the sensor scan angle and should be accurate to within a degree. The sensor azimuth angles were determined from plotting the center points of a nadir view camera on an air photo of the area and connecting them to determine the aircraft heading. Because of the errors in this method, view azimuth accuracy is probably no more than two to three degrees. Solar zenith and azimuth were determined computationally from the time at the beginning of each flight line and should be within a degree. Sites referred to as 0 and 99 in the tables are observations of water.

Related Data Sets:

Not available.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Forrest G. Hall
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Title of Investigation:

Biophysical, Morphological, Canopy Optical Property, and Productivity Data on the Superior National Forest.

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3. Theory of Measurements:

Not available.

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

Aircraft.

Source/Platform:

NASA C-130.

Source/Platform Mission Objectives:

Not available.

Key Variables:

Radiance, reflectance.

Principles of Operation:

Not available.

Sensor/Instrument Measurement Geometry:

Not available.

Manufacturer of Sensor/Instrument:

Not available.

Calibration:

Not available.

5. Data Acquisition Methods:

Not available.

6. Observations:

Data/Field Notes:

Not available.

7. Data Description:

Spatial Characteristics:

The study area covered a 50 x 50 km area centered at approximately 48 degrees North latitude and 92 degrees West longitude in northeastern Minnesota at the southern edge of the North American boreal forest.

Temporal Characteristics:

TMS data were collected and processed for three days: July 13 and August 6, 1983; and June 28, 1984.

Data Characteristics:

Variable Name/ Long Name Description		SAS Type	Generic Type
1 obs_datc "Observation date (DD-MON-YY) (e.g. 01-JAN-90)"	OBS_DATE	$ 12	DATE
2 site_id "Site ID"	SITE_ID	8	NUMBER(4,0)
3 sol_zen "Average solar zenith angle in decimal degrees relative to the observer"	SOLAR_ZEN	8	NUMBER(5,2)
4 sol_az "Average solar azimuth angle in decimal degrees relative to the observer"	SOLAR_AZM	8	NUMBER(5,2)
5 view_zen "View zenith angle of the instrument in decimal degrees relative to the observer"	VIEW_ZEN	8	NUMBER(5,2)
6 view_az "View azimuth angle of the instrument in decimal degrees, relative to the observer"	VIEW_AZM	8	NUMBER(5,2)
7 rfl1	REFL1	8	NUMBER(4,2)

"Average percent of reflectance in TMS channel 1 (0.458-0.519)"

8	std1	SD1	8	NUMBER(4,2)
"Standard deviation of reflectance in TMS channel 1"				
9	rfl2	REFL2	8	NUMBER(4,2)
"Average percent of reflectance in TMS channel 2 (0.529-0.603)"				
10	std2	SD2	8	NUMBER(4,2)
"Standard deviation of reflectance in TMS channel 2"				
11	rfl3	REFL3	8	NUMBER(4,2)
"Average percent of reflectance in TMS channel 3 (0.633-0.697)"				
12	std3	SD3	8	NUMBER(4,2)
"Standard deviation of reflectance in TMS channel 3"				
13	rfl4	REFL4	8	NUMBER(4,2)
"Average percent of reflectance in TMS channel 4 (0.767-0.910)"				
14	std4	SD4	8	NUMBER(4,2)
"Standard deviation of reflectance in TMS channel 4"				
15	rfl5	REFL5	8	NUMBER(4,2)
"Average percent of reflectance in TMS channel 5 (1.13-1.35)"				
16	std5	SD5	8	NUMBER(4,2)
"Standard deviation of reflectance in TMS channel 5"				
17	rfl6	REFL6	8	NUMBER(4,2)
"Average percent of reflectance in TMS channel 6 (1.57-1.71)"				
18	std6	SD6	8	NUMBER(4,2)
"Standard deviation of reflectance in TMS channel 6"				

19 rfl7 "Average percent of reflectance in TMS channel 7 (2.10-2.38)"	REFL7	8	NUMBER(4,2)
20 std7 "Standard deviation of reflectance in TMS channel 7"	SD7	8	NUMBER(4,2)
21 flight "Flight line as recorded in the flight summary logs"	FLIGHT_LINE	8	NUMBER(2,0)

Sample Data Record:

obs_datc	site_id	sol_zen	sol_az	view_zen	view_az	rfl1	std1	rfl2	std2	rfl3	std3	rfl4	std4	rfl5	std5	rfl6	std6
"13-JUL-83"	2	56.16	94.33	3	90	3.97	0.26	4.47	0.36	2.31	0.28	14.34	1.74	16.95	1.7	4.57	0.45
"13-JUL-83"	2	53.84	97.1	33.7	88	2.54	0.18	3	0.28	1.33	0.2	13.77	1.13	16.61	1.02	4.34	0.29
"13-JUL-83"	2	49.4	102.75	17.71	50	3.91	0.21	4.75	0.41	2.68	0.25	15.04	1.15	18.4	1.33	5.03	0.42
"13-JUL-83"	2	51.53	99.97	20.86	268	6.33	0.36	7.82	0.68	4.7	0.39	21.21	1.75	25.94	1.82	8.21	0.73
"13-JUL-83"	2	44.13	110.37	23.29	320	6.01	0.33	8.42	0.61	5.48	0.4	23.42	2.4	29.13	2.36	10.26	1.01
"13-JUL-83"	2	47.46	105.41	19.57	233	4.71	0.21	6.17	0.35	3.7	0.31	18.14	1.64	22.81	1.54	6.95	0.55
"13-JUL-83"	14	56.16	94.33	1.14	90	3.92	0.22	4.37	0.46	2.33	0.37	13.72	1.7	16.44	1.69	4.46	0.56
"13-JUL-83"	14	53.84	97.1	33.14	88	2.46	0.1	2.9	0.32	1.44	0.17	12.29	1.14	15.61	1.06	4.63	0.26
"13-JUL-83"	14	51.53	99.97	22.28	268	6.39	0.21	8.01	0.35	4.84	0.45	20.76	0.96	25.79	1.14	8.5	0.67
"13-JUL-83"	14	44.13	110.37	25.57	320	6.4	0.14	8.92	0.3	5.83	0.34	24.3	0.87	29.46	1.02	9.74	0.51
"13-JUL-83"	57	56.16	94.33	7.29	90	3.38	0.31	3.88	0.57	1.99	0.28	12.02	1.67	14.82	1.87	4.18	0.71
"13-JUL-83"	57	53.84	97.1	38	88	1.94	0.13	2.62	0.26	1.16	0.16	11.3	0.59	14.6	0.51	4.37	0.32
"13-JUL-83"	57	51.53	99.97	16.29	268	5.92	0.19	7.61	0.56	4.69	0.29	19.71	1.62	25.62	2.06	8.78	0.81
"13-JUL-83"	57	44.13	110.37	3	320	3.69	0.24	5.31	0.56	3.23	0.43	16.78	1.88	21.34	2	6.42	0.81
"06-AUG-83"	0	48.96	113.47	44.89	313.5	2.58	0.08	1.76	0.14	1.27	0	0.52	0	0.46	0.27	0.22	0.16
"06-AUG-83"	0	38.5	135.18	1.69	270	2.48	0.07	1.87	0.13	1.43	0.09	0.32	0	0.5	0.22	0.4	0.12
"06-AUG-83"	0	35.7	144.41	46.52	40.5	1.64	0.09	1.36	0.12	1.04	0.13	0.14	0	0.22	0.22	0.11	0.1
"06-AUG-83"	0	44.38	121.5	17.4	266.5	2.65	0.1	2.03	0.16	1.51	0	0.29	0	0.45	0	0.03	0.16
"06-AUG-83"	0	41.76	126.96	33.57	262.5	2.55	0.15	1.84	0.2	1.39	0.13	0.36	0	0.44	0.24	0.13	0.17
"06-AUG-83"	0	37.03	139.86	7.03	36	2.43	0.1	1.8	0.11	1.35	0.08	0.46	0	0.41	0.22	0.28	0.14

```
"06-AUG-83"    0        45.82        118.8      1.25       313       3.01      0.13     1.98
0.1       1.24      0.15       0.22      0.16       0.28      0         0.1       0.14
"06-AUG-83"   72        48.96        113.47    37.88       313.5     3.46      0.15     4.56
0.33      2.54      0.17      39.99      1.99      45.44      2.13      11.69     0.52
"06-AUG-83"   72        37.03        139.66     5.08       216       3.92      0.26     5.31
0.45      3.33      0.35      39.61      3.2       48.3       3.58      14.29     1.15
"06-AUG-83"   72        41.76        126.95    33.37       262.5     3.59      0.2      4.59
0.34      2.83      0.25      37.79      2.51      44.14      2.65      12.13     0.72
"06-AUG-83"   72        44.38        121.5     18.08       266.5     4.11      0.17     5.14
0.32      3.14      0.23      39.2       2.73      47.41      3.09      13.21     0.99
"06-AUG-83"   72        35.7         144.41    39.41        40.5     3.81      0.19     5.18
0.25      3.06      0.23      38.48      2.32      47.33      2.37      13.61     0.54
"06-AUG-83"   72        38.5         135.18    0.93         90       4.11      0.23     5.45
0.49      3.27      0.33      39.73      3.33      49.15      3.26      14.93     1.04
"06-AUG-83"   72        45.82        118.8     11.56       133       4.59      0.53     5.74
0.78      3.34      0.59      42.05      4.34      52.31      4.66      15.77     1.3
```

Footnote:

> For presentation in this document, some padding blanks may have been eliminated between columns in the Sample Data Record. Due to the many fields in this data file, these columns will wrap while viewing. The actual data files, however, are column delimited with an adequate record length to prevent wrapping. See the *Data Format Section* for conventions used for missing data values in the data file.

8. Data Organization:

Data are sorted by observation date (obs_datc) and study site (site_id). Key fields in each record are obs_datc and site_id.

Data Granularity:

This data set consists of a single ASCII file containing radiance and reflectance measurements for multiple observation dates and sites in the Superior National Forest.

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

The data files associated with this data set consist of numeric and character fields of varying lengths aligned in columns. The first row of each data file contains the 8 character SAS variable name that links to the data format definition file. Character fields are enclosed in double quotes and numeric fields are listed without quotes.

Missing data values can be of two varieties:

1. Values that were identified as missing in the original data files. Missing numeric values of this type are identified in these data as -999.

2. Those holes that were created as a result of combining files that contained a slightly different variable set. Missing values of this type are identified in these data files as empty double quotes for character fields and a single period, '.' for numeric fields.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

Not available.

Data Processing Sequence:

Processing Steps:

Several processing steps were required to turn raw TMS data into physically meaningful numbers for the test sites.

The TMS scanner sweeps through view angles of plus or minus 50 degrees. This introduces both geometric distortions and varying atmospheric path lengths across the scan line. At extreme scan angles, a pixel covers an area on the ground several times larger than at nadir. At the nominal 5000 foot altitude flown, a nadir pixel covers 3.81 meters along the scan, expanding to 9.22 meters at 50 degrees off nadir. To compensate for this distortion, the data were linearly resampled to a constant pixel size, the same size as the nadir pixel. The scan angle corrected images from different flight lines were then registered to a common image. The registration algorithm used control points to remove distortions locally rather than globally, and was effective in correcting for perturbations introduced by variations in aircraft motion. Sites were located in the imagery using photographs, descriptions of site locations, first hand knowledge and maps. Digital count values for areas four by four pixels, approximately 16 by 16 meters, were extracted from each flight line. Using the calibration data provided for each scan line, these values were converted to radiance values by subtracting the low blackbody radiance count and multiplying by the radiance calibration factor.

The TMS radiance values were converted to reflectance using values for insolation, atmospheric transmittance, and path scattered radiance for the appropriate solar and view angles. No measurement of these values were made, so the LOWTRAN6 atmosphere model was used to generate them. Scattering contributions calculated from the path between the canopy and the sensor were subtracted from the sensor detected radiances and divided by the incident flux to generate reflectance factors.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

None known at this revision.

Calculated Variables:

Not available.

Graphs and Plots:

None available at this revision.

10. Errors:

Sources of Error:

Not available.

Quality Assessment:

Data Validation by Source:

Not available.

Confidence Level/Accuracy Judgment:

Not available.

Measurement Error for Parameters:

Not available.

Additional Quality Assessments:

Not available.

Data Verification by Data Center:

The Superior National Forest data were received from the Goddard Space Flight Center in three media:

- As data dumps from the original Oracle SNF database maintained by GSFC, transferred electronically from the GSFC system to the ORNL system;

- As ASCII files that mirrored the tables published in the Tech Memo; and
- As hard copy (Tech Memo).

Data from both electronic sources were input into SAS by ORNL DAAC data management staff and compared using computer code developed to process the SNF data. In many cases, the data values from both sources were found to be identical. In some cases, however, differences were identified and the providers of the data were consulted to resolve inconsistencies.

Additionally, some variable columns were available in one source, but not the other for various reasons. For example, some calculated variables/columns were provided in the ASCII files (reflecting the Tech Memo tables) that were not stored in the Oracle database for purposes of space conservation.

For similar reasons, coded values were used for many of the site and species identifier variables. A separate reference table was provided to link the coded variable with its definition (e.g., the SPECIES_REF file and the SITE_REF file).

The database produced by the ORNL DAAC is a hybrid product that is a composite of data and information extracted from all three source media. In data sets where coded variables were included, the code definition variables have been added to improve usability of the data set as a stand-alone product.

Therefore the ASCII files that are available through the ORNL DAAC on-line search and order systems are output from a data set that is a product of the essential core of numeric data provided by the data source (GSFC), augmented with additional descriptive information provided by GSFC and reorganized by the ORNL DAAC into a data structure consistent with other similar data sets maintained by the ORNL DAAC.

11. Notes:

Limitations of the Data:

Not available.

Known Problems with the Data:

None known at this revision.

Usage Guidance:

Not available.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

These data are useful in the analysis of the bi-directional reflectance function of forest canopies.

13. Future Modifications and Plans:

None known at this revision.

14. Software:

Not available.

15. Data Access:

Contact Information:

ORNL DAAC User Services
Oak Ridge National Laboratory
Telephone: (865) 241-3952
Fax: (865) 574-4665

E-mail: ornldaac@ornl.gov

Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
Telephone: (865) 241-3952
Fax: (865) 574-4665
E-mail: ornldaac@ornl.gov

Procedures for Obtaining Data:

Users may order data by telephone, electronic mail, or fax. Data are available via FTP or on CD-ROM. Data are also available via the World Wide Web at http://daac.ornl.gov.

Data Center Status/Plans:

The Superior National Forest Data are available from the ORNL DAAC. Please contact the ORNL DAAC User Services Office for the most current information about these data.

16. Output Products and Availability:

Available via FTP or on CD-ROM.

17. References:

Not available.

Archive/DBMS Usage Documentation.

Contact the ORNL DAAC, Oak Ridge, Tennessee (see the *Data Center Identification Section*).

18. Glossary of Terms:

A general glossary is located at EOSDIS Glossary.

19. List of Acronyms:

TMS Thematic Mapper Simulator URL Uniform Resource Locator

A general list of acronyms is available at http://cdiac.ornl.gov/pns/acronyms.html.

20. Document Information:

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February 25, 1997.

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Superior National Forest, NASA Technical Memorandum 104568, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A., 1992.

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