Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall, Editor

Volume 89

BOREAS Level-0 NS001 TMS Imagery: Digital Counts in BIL Format

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National Aeronautics and Space Administration

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September 2000
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Summary

For BOREAS, the NS001 TMS imagery, along with the other remotely sensed images, was collected in order to provide spatially extensive information over the primary study areas. This information includes detailed land cover and biophysical parameter maps such as fPAR and LAI. Data collections occurred over the study areas during the 1994 field campaigns.

Note that the level-0 NS001 data are not contained on the BOREAS CD-ROM set. An inventory listing file is supplied on the CD-ROM to inform users of the data that were collected. See Section 15 for information about how to acquire actual level-0 NS001 images.

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1. Data Set Overview

1.1 Data Set Identification
BOREAS Level-0 NS001 TMS Imagery: Digital Counts in BIL Format

1.2 Data Set Introduction
The BOREal Ecosystem-Atmosphere Study (BOREALS) Staff Science effort covered those activities that were BOREAS community-level activities or required uniform data collection procedures across sites and time. These activities included the acquisition, processing, and archiving of eight-band NS001 Thematic Mapper Simulator (TMS) Multispectral Scanner (MSS) data collected on the National Aeronautics and Space Administration’s (NASA’s) C-130 aircraft. The NS001 provided spectral image data very similar to that of the Landsat Thematic Mapper (TM).
1.3 Objective/Purpose
The BOREAS Staff Science effort covered those activities that were BOREAS community-level activities or required uniform data collection procedures across sites and time. These activities included the acquisition, processing, and archiving of eight-band NS001 TMS MSS data collected on NASA's C-130 aircraft.

For BOREAS, the NS001 TMS imagery, along with the other remotely sensed images, was collected in order to provide spatially extensive information over the primary study areas. This information includes detailed land cover and biophysical parameter maps such as fraction of Photosynthetically Active Radiation (fPAR), and Leaf Area Index (LAI).

1.4 Summary of Parameters
NS001 level-0 image data in the BOREAS Information System (BORIS) contain the following parameters:
• Original housekeeping and calibration information and image bands 1 to 8 in the Ames Research Center (ARC) Band Interleaved by Line (BIL) format.

1.5 Discussion
BORIS staff processed the NS001 TMS level-0 images by:
• Extracting pertinent header information from the level-0 image product and placing it in an American Standard Code for Information Interchange (ASCII) file on disk
• Reading the information in the disk file and loading the online data base with needed information

1.6 Related Data Sets
BOREAS Level-0 C-130 Navigation Data
BOREAS Level-0 C-130 Aerial Photography
BOREAS Level-1b ASAS Imagery
BOREAS Level-1b MAS Imagery: At-sensor Radiance, Relative X and Y Coordinates
BOREAS Level-0 TIMS Imagery: Digital Counts in BIL Format
BOREAS Level-1b TIMS Imagery: At-sensor Radiance in BSQ Format

2. Investigator(s)

2.1 Investigator(s) Name and Title
BOREAS Staff Science

2.2 Title of Investigation
BOREAS Staff Science Aircraft Data Acquisition Program

2.3 Contact Information

Contact 1:
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(415) 604-6253
(415) 604-4987 (fax)
jmyers@mail.arc.nasa.gov
3. Theory of Measurements

The NASA Earth Resources Aircraft Program at ARC operates the C-130 aircraft to acquire data for Earth science research. The NS001 MSS used on the C-130 aircraft collects radiance measurements in the seven Landsat-4 and -5 TM bands plus a band from 1,000 to 1,300 nm. Therefore, when reflected or emitted radiation from Earth surface features is measured from the aircraft, inferences can be made about Landsat satellite measurements.

Thematic considerations have dictated, within technical constraints, the choice of spectral band position and width in the NS001 sensor. Eight bands were selected, seven of which correspond to Landsat TM bands. These bands were chosen after many years of analysis for their value in discrimination of several Earth surface features. A blue (0.45 to 0.52 μm) band provides increased penetration of water bodies as well as supporting analyses of land use, soil, and vegetation characteristics. The lower wavelength cutoff is just below the peak transmittance of clear water, while the upper wavelength cutoff is the limit of blue chlorophyll absorption for healthy green vegetation. Wavelengths below 450 nm are substantially influenced by atmospheric scattering and absorption.

A green (0.52 to 0.60 μm) band spans the region between the blue and red chlorophyll absorption bands and therefore corresponds to the green reflectance of healthy vegetation. A red (0.63 to 0.69 μm) band includes the chlorophyll absorption band of healthy green vegetation and represents one of the most important bands for vegetation discrimination. The latter is also useful for soil and geological boundary delineations. A reflective-infrared (0.76 to 0.90 μm) band is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification and emphasizes soil-crop and land-water contrasts.

Two of the three mid-infrared (1.00 to 1.30 μm; 1.55 to 1.75 μm) bands are sensitive to the turgidity or amount of water in plants. Such information is useful in crop drought studies and in plant vigor investigations. In addition, these are two of the few bands that can be used to discriminate between clouds, snow, and ice, which is very important in hydrologic research. The other mid-infrared band (2.08 to 2.35 μm) is important for the discrimination of geologic rock formations. It has been shown to be particularly effective in identifying zones of hydrothermal alteration in rocks. Finally, the thermal infrared (10.4 to 12.5 μm) band measures the amount of infrared radiant flux emitted from surfaces. The apparent temperature is a function of the emissivities and true or kinetic temperature of the surface. It is useful for geothermal activity location, thermal inertia mapping for geologic investigations, vegetation classification, vegetation stress analysis, and soil moisture studies.

4. Equipment

4.1 Sensor/Instrument Description

The NS001 TMS instruments are designed to simulate spectral, spatial, and radiometric characteristics of the TM sensor on the Landsat-4 and -5 spacecraft. The NS001 is generally flown at medium altitudes aboard NASA’s C-130 aircraft based at ARC and provides 12.2-meter resolution at nadir at an altitude of 4,878 meters (16,000 feet). The NS001 sensor differs slightly from the Landsat TM instruments. It has seven spectral channels that are very similar to those of the TM sensor, but has an additional infrared channel, as follows:

Comparable
4.1.1 Collection Environment
As part of the BOREAS Staff Science data collection effort, the ARC Medium Altitude Aircraft
Branch collected and processed eight-band NS001 TMS MSS data to BOREAS level-0 products. The
NS001 was flown on NASA's C-130 aircraft during the BOREAS mission (see the BOREAS
Experiment Plan for flight pattern details and objectives).

Maintenance and operation of the instrument are the responsibility of ARC. The C-130
Experimenter's Handbook (supplemental) produced by the Medium Altitude Aircraft Branch at ARC
provides a description of the instrument, calibration procedures, and data format. Data from the level-0
tapes provided by ARC can be decoded based on the contents of the handbook.

NS001 data may be intentionally overscanned; e.g., operated at some integral multiple of the
desired scan rate and then subsampled in preprocessing. The subsampling factor is reported under the
label "demagnification factor."

4.1.2 Source/Platform
NASA's C-130 Earth Resources Aircraft.

4.1.3 Source/Platform Mission Objectives
The original purpose of the scanner was to provide low-altitude data in the Landsat TM bands for
analysis prior to the launch of the satellite, and to provide calibration information from under-flights
subsequent to the launch of the satellite.

4.1.4 Key Variables
Emitted radiation, reflected radiation, and temperature.

4.1.5 Principles of Operation
Design parameters of the NS001 are based on the specifications of the Landsat TM with respect to
spectral band characteristics. A single spectrometer disperses the energy to cover the first six bands
from 0.45 µm to 1.75 µm. An array, employing silicon, germanium, and indium antimonide detectors,
is used. Band 7 is separated by a dichroic bandpass filter. Band 8, in the 10.4 µm to 12.5 µm region,
is detected by a cooled mercury-cadmium-telluride detector.

Variable velocity over height (V/H) conditions are compensated by a variable speed motor that
drives the scan mirror.

Each channel uses a preamplifier to provide initial video amplification. Gain and level control of
video signals are adjustable from the operator's control panel. Each channel is digitized to an 8-bit
resolution and is multiplexed with calibration and housekeeping data.

4.1.6 Sensor/Instrument Measurement Geometry

<table>
<thead>
<tr>
<th>NS001 Channel</th>
<th>Wavelength, µm</th>
<th>Landsat TM Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.45-0.52</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.52-0.60</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0.63-0.69</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0.76-0.90</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>1.00-1.30</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>1.55-1.75</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>2.08-2.35</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>10.40-12.5</td>
<td>6</td>
</tr>
</tbody>
</table>

Sensor footprint is 12.2 m by 12.2 m at nadir at 4,878 meters altitude.

4.1.7 Manufacturer of Sensor/Instrument
4.2 Calibration

The NS001 includes two full-aperture blackbodies and one integrating sphere within the scan mirror cavity. They are viewed each scan by the instrument, and the responses are embedded in the data stream. Blackbody temperatures and lamp current data are multiplexed with scanner output data. The blackbody irradiance is determined by its monitored temperature and estimated emissivity. The blackbodies are also cross-checked periodically by comparing the NS001 responses to the blackbodies and an external precision blackbody. The internal sphere is calibrated by reference to an external light source.

The principal source used for calibrating the internal sphere for BOREAS in 1994 was a 76 cm diameter integrating sphere owned by ARC and calibrated by the Standards and Calibration Office at GSFC. The sphere contains 12 internally mounted quartz halogen lamps. Estimated uncertainty in the calibration of the sphere is +/-5%. The April 1994 calibration of the sphere was used to calibrate the internal calibration source in the NS001 in 1994.

4.2.1 Specifications

The wavelength ranges (in μm) of the bands for the NS001 are:

<table>
<thead>
<tr>
<th>Band</th>
<th>Detector</th>
<th>Wavelength (in μm)</th>
<th>Noise Equivalent (NE) (delta P) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Si</td>
<td>0.458 - 0.519</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>Si</td>
<td>0.529 - 0.603</td>
<td>0.5</td>
</tr>
<tr>
<td>3</td>
<td>Si</td>
<td>0.633 - 0.697</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>Si</td>
<td>0.767 - 0.910</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>Ge</td>
<td>1.13 - 1.35</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>Ge</td>
<td>1.57 - 1.71</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>InSb</td>
<td>2.10 - 2.38</td>
<td>2.0</td>
</tr>
<tr>
<td>8</td>
<td>HgCdTe</td>
<td>10.9 - 12.3</td>
<td>NE(delta T) = 0.25 K</td>
</tr>
</tbody>
</table>

DESIGN DATA:

- IFOV: 2.5 mrad
- Across-track FOV: 100 degrees
- Nominal aperture diameter: 10.16 cm
- Effective aperture area: 72.4 cm²
- f-number: 1.85
- Primary focal length: 18.8 cm
- Inflight calibration: Integrating sphere and two controllable blackbodies
- Short wavelength array temperature: 255 K
- V/H range: Variable 0.025 to 0.25
- Scan rate: Variable 10 to 100 scans/sec.
- Scan speed stability: One-third of the IFOV, scan line to scan line
- Data quantization: 8 bits (256 discrete levels)
- Number of video samples/scan line: 699
- Roll compensation: +/-15 degrees
- Scan mirror: 45-degree rotating mirror

4.2.1.1 Tolerance
The NS001 channels were designed for NE reflectance differences for the channels, represented by the radiometric sensitivity [NE(delta P) %; NE(delta T) K] shown in Section 4.2.1.

4.2.2 Frequency of Calibration

An integrating sphere and two controllable thermal blackbodies (BB1 and BB2) are integral to the NS001 scanner. Each is viewed once during a complete revolution of the scan mirror. The two thermal blackbodies are principally used to span the recorded thermal image, thereby providing a scaling factor for the measured data. The surface of BB2 is also used to provide the tare value (darkest object viewed per sweep) for the seven nonthermal detectors. Tare value is artificially set above zero counts (e.g., 8-10 counts) to compensate for any system drift.

For BOREAS, one of the blackbodies is used for the internal lamp offset. The average of the two blackbodies is used for the scene offset.

4.2.3 Other Calibration Information

4.2.3.1 Reflective Band Calibration

The BB2 View is used for the internal source offset; i.e., the gain is calculated in effect as:

\[
\text{Gain} = \frac{\text{Ref. Lamp View} - \text{BB2 View}}{\text{Ref. Lamp Spectral Radiance}}
\]

The reference lamp spectral radiance is determined by preseason calibration relative to the integrating sphere. The apparent scene spectral radiance in Watts/(m² sr μm) can then be calculated as:

\[
\frac{\text{pixel value} - \left(\frac{\text{BB 1 View} + \text{BB2 View}}{2}\right)}{\text{Gain}}
\]

4.2.3.2 Thermal Band Calibration

GSFC Gain (G), Offset (O), as found in the header summary file(s) are calculated as follows:

a) Calculate blackbody radiances, Lw(mW/cm²/sr/μm) (assume emissivity=1) for BB1 and BB2 temperatures T(K) e.g.

For example:

\[
L_{w,\text{bb1}} = \frac{K_1}{\exp(K_2/T_{bb1}) - 1}
\]

where:  
K1 = 607.05 W/cm²/sr/μm  
K2 = 1258.39 K

K1, K2 were "best fit" parameters for the temperature range of 273-323 K using the 8/87 NS001 spectral data and the Planck equation.

b) \[G = \left(\frac{\text{BB2 View} - \text{BB1 View}}{L_w,\text{BB2} - L_w,\text{BB1}}\right)\]

\[(\text{DN/mW/cm²/sr/μm})\]

\[O = \text{BB1 View} - G \times L_w,\text{BB1} \ (\text{DN})\]

Target Radiance (Lw) can then be calculated as:

\[(\text{pixel value} - O) / G\]

and at-sensor apparent temperature as:

\[T = \frac{K_2}{\ln(K_1/L_w + 1)}\]
5. Data Acquisition Methods

As part of the BOREAS Staff Science data collection effort, ARC Medium Altitude Aircraft Branch collected and processed 8-band NS001 TMS MSS data to BOREAS level-0 products. The NS001 was flown on NASA's C-130 aircraft during the BOREAS mission (see the BOREAS Experiment Plan for flight pattern details and objectives).

Maintenance and operation of the instrument are the responsibility of ARC. The C-130 Experimenter's Handbook (supplemental) produced by the Medium Altitude Aircraft Branch at ARC provides a description of the instrument, calibration procedures, and data format. Data from the level-0 tapes provided by ARC can be decoded based on the contents of the handbook.

NS001 data may be intentionally overscanned; e.g., operated at some integral multiple of the desired scan rate and then subsampled in preprocessing. The subsampling factor is reported under the label "demagnification factor."

6. Observations

6.1 Data Notes

See Section 11.

6.2 Field Notes

Flight summary reports and verbal records on videotapes are available for the BOREAS NS001 data.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The BOREAS level-0 NS001 TMS images cover portions of the Southern Study Area (SSA) and the Northern Study Area (NSA). A few images were acquired for the transect area between the SSA and the NSA. The SSA and the NSA are located in the southwest and northeast portions of the overall BOREAS region.

The North American Datum of 1983 (NAD83) corner coordinates of the SSA are:

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>54.321 N</td>
<td>106.228 W</td>
</tr>
<tr>
<td>Northeast</td>
<td>54.225 N</td>
<td>104.237 W</td>
</tr>
<tr>
<td>Southwest</td>
<td>53.515 N</td>
<td>106.321 W</td>
</tr>
<tr>
<td>Southeast</td>
<td>53.420 N</td>
<td>104.368 W</td>
</tr>
</tbody>
</table>

The NAD83 corner coordinates of the NSA are:

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>56.249 N</td>
<td>98.825 W</td>
</tr>
<tr>
<td>Northeast</td>
<td>56.083 N</td>
<td>97.234 W</td>
</tr>
<tr>
<td>Southwest</td>
<td>55.542 N</td>
<td>99.045 W</td>
</tr>
<tr>
<td>Southeast</td>
<td>55.379 N</td>
<td>97.489 W</td>
</tr>
</tbody>
</table>
7.1.2 Spatial Coverage Map
Not available.

7.1.3 Spatial Resolution
Typical altitudes for BOREAS were around 5,000 m, producing a 12.5-m pixel at nadir given the NS001's 2.5-mrad IFOV.

7.1.4 Projection
The BOREAS level-0 NS001 images are stored in their original data collection frame with increasing pixel sizes from nadir to the scanning extremes based on the scan angle.

7.1.5 Grid Description
The BOREAS level-0 NS001 images are stored in their original data collection frame with increasing pixel sizes from nadir to the scanning extremes based on the scan angle.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
The data were collected during BOREAS' Field Campaigns, covering the period from 16-Apr-1994 through 17-Sep-1994.

7.2.2 Temporal Coverage Map

<table>
<thead>
<tr>
<th>IFC#</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFC-1</td>
<td>26-May-1994 -- 08-Jun-1994</td>
</tr>
<tr>
<td>IFC-3</td>
<td>06-Sep-1994 -- 17-Sep-1994</td>
</tr>
</tbody>
</table>

7.2.3 Temporal Resolution
Images were acquired on multiple days during each of the IFCs.

7.3 Data Characteristics
A level-0 NS001 image from BORIS is contained in a single file. Each record of a level-0 NS001 data file contains 6,000 bytes. The number of records in a file varies depending on the length of the flight line. Detailed information about the contents of the data file is provided in Section 8 of this document.

7.3.1 Parameter/Variable
The main parameter contained in the image data files is:
Digital Number (DN). The other parameters contained in the NS001 housekeeping are described in section 8.2.

The parameters contained in the inventory listing file on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL_COVERAGE</td>
</tr>
<tr>
<td>DATE_OBS</td>
</tr>
<tr>
<td>START_TIME</td>
</tr>
<tr>
<td>END_TIME</td>
</tr>
<tr>
<td>PLATFORM</td>
</tr>
<tr>
<td>INSTRUMENT</td>
</tr>
</tbody>
</table>
7.3.2 Variable Description/Definition

For the image data files:

Digital Number (DN) - The quantized DN derived by the NS001 TMS scanning system for the respective channel.

The descriptions of the parameters contained in the inventory listing file on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL_COVERAGE</td>
<td>The general term used to denote the spatial area over which the data were collected.</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>The date on which the data were collected.</td>
</tr>
<tr>
<td>START_TIME</td>
<td>The starting Greenwich Mean Time (GMT) for the data collected.</td>
</tr>
<tr>
<td>END_TIME</td>
<td>The ending Greenwich Mean Time (GMT) for the data collected.</td>
</tr>
<tr>
<td>PLATFORM</td>
<td>The object (e.g., satellite, aircraft, tower, person) that supported the instrument.</td>
</tr>
<tr>
<td>INSTRUMENT</td>
<td>The name of the device used to make the measurements.</td>
</tr>
<tr>
<td>NUM_BANDS</td>
<td>The number of spectral bands in the data.</td>
</tr>
<tr>
<td>PLATFORM_ALTITUDE</td>
<td>The nominal altitude of the data collection platform above the target.</td>
</tr>
<tr>
<td>MIN_SOLAR_ZEN_ARG</td>
<td>The minimum angle from the surface normal (straight up) to the sun during the data collection.</td>
</tr>
<tr>
<td>MAX_SOLAR_ZEN_ARG</td>
<td>The maximum angle from the surface normal (straight up) to the sun during the data collection.</td>
</tr>
<tr>
<td>MIN_SOLAR_AZ_ARG</td>
<td>The minimum azimuthal direction of the sun during data collection expressed in clockwise</td>
</tr>
</tbody>
</table>
MAX_SOLAR_AZ_ANG
The maximum azimuthal direction of the sun during data collection expressed in clockwise increments from North.

C130MISSION_ID
The mission identifier assigned to the C130 mission in the form of YY-DDD-FF where YY is the last two digits of the fiscal year, DDD is the deployment number for "official" C130 missions and is day of year for non-"official" C130 missions (i.e., no site coverage), and FF is the flight number within the given deployment (00 is given for non-"official" C130 missions). An example would be 94-006-04.

C130_LINE_NUM
The number of the C130 line in its flights over the BOREAS area as given in the flight logs. Zero values are given for non-"official" C130 missions and for data between C130 sites or lines.

C130_RUN_NUM
The number of the C130 run in its flights over the BOREAS area as given in the flight logs. Zero value is given for non-"official" C130 missions and data between C130 sites, lines or runs.

C130_SITE
The C130 site designator as given in the flight logs. PRE is used for data taken from the airport to the first "official" C130 site, BTW is used for data taken between two "official" C130 sites, DSC is used for data taken after the last "official" C130 site, TRN is used for transect data, and YTH and YPA are used for data taken at the YTH and YPA airports (aircraft never left the ground).

BAND_QUALITY
The data analyst's assessment of the quality of the spectral bands in the data.

CLOUD_COVER
The data analyst's assessment of the cloud cover that exists in the data.

NS001_MEAN_FRAME_STATUS
The mean frame status calculated from the respective values on the digital tape of NS001 data collected during the given flight. Values other than zero indicate interpolated, repeated, or zero filled lines in the image.

NW_LATITUDE
The NAD83 based latitude coordinate of the northwest corner of the minimum bounding rectangle for the data.

NW_LONGITUDE
The NAD83 based longitude coordinate of the northwest corner of the minimum bounding rectangle for the data.

NE_LATITUDE
The NAD83 based latitude coordinate of the northeast corner of the minimum bounding rectangle for the data.

NE_LONGITUDE
The NAD83 based longitude coordinate of the northeast corner of the minimum bounding rectangle for the data.

SW_LATITUDE
The NAD83 based latitude coordinate of the south
SW_LONGITUDE  The NAD83 based longitude coordinate of the southwest corner of the minimum bounding rectangle for the data.
SE_LATITUDE  The NAD83 based latitude coordinate of the southeast corner of the minimum bounding rectangle for the data.
SE_LONGITUDE  The NAD83 based longitude coordinate of the southeast corner of the minimum bounding rectangle for the data.
CRTFCN_CODE  The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).

### 7.3.3 Unit of Measurement

For the image data files: **Digital Number (DN) - counts**

The measurement units for the parameters contained in the inventory listing file on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL COVERAGE</td>
<td>[none]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[DD-MON-YY]</td>
</tr>
<tr>
<td>START_TIME</td>
<td>[HHMM GMT]</td>
</tr>
<tr>
<td>END_TIME</td>
<td>[HHMM GMT]</td>
</tr>
<tr>
<td>PLATFORM</td>
<td>[none]</td>
</tr>
<tr>
<td>INSTRUMENT</td>
<td>[none]</td>
</tr>
<tr>
<td>NUM_BANDS</td>
<td>[counts]</td>
</tr>
<tr>
<td>PLATFORM_ALTITUDE</td>
<td>[meters]</td>
</tr>
<tr>
<td>MIN_SOLAR_ZEN_Ang</td>
<td>[degrees]</td>
</tr>
<tr>
<td>MAX_SOLAR_ZEN_Ang</td>
<td>[degrees]</td>
</tr>
<tr>
<td>MIN_SOLAR_AZ_Ang</td>
<td>[degrees]</td>
</tr>
<tr>
<td>MAX_SOLAR_AZ_Ang</td>
<td>[degrees]</td>
</tr>
<tr>
<td>C130_MISSION_ID</td>
<td>[none]</td>
</tr>
<tr>
<td>C130_LINE_NUM</td>
<td>[none]</td>
</tr>
<tr>
<td>C130_RUN_NUM</td>
<td>[none]</td>
</tr>
<tr>
<td>C130_SITE</td>
<td>[none]</td>
</tr>
<tr>
<td>BAND_QUALITY</td>
<td>[none]</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>[none]</td>
</tr>
<tr>
<td>NS001_MEAN_FRAME_STATUS</td>
<td>[unitless]</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>NW_LONGITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>NE_LATITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>NE_LONGITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>SW_LATITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>SW_LONGITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>SE_LATITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>SE_LONGITUDE</td>
<td>[degrees]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[none]</td>
</tr>
</tbody>
</table>
7.3.4 Data Source

The level-0 NS001 TMS data were collected by the NS001 instrument on the C130 aircraft. The data were processed from the aircraft tapes and supplied to BOREAS by the Medium Altitude Aircraft Branch at ARC. The source of the parameter values contained in the inventory listing file on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL_COVERAGE</td>
<td>[Determined from latitude and longitude information provided in the NASA Ames flight summary reports]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Software derived from NS001 housekeeping data]</td>
</tr>
<tr>
<td>START_TIME</td>
<td>[Software derived from NS001 housekeeping data]</td>
</tr>
<tr>
<td>END_TIME</td>
<td>[Software derived from NS001 housekeeping data]</td>
</tr>
<tr>
<td>PLATFORM</td>
<td>[Data base constant]</td>
</tr>
<tr>
<td>INSTRUMENT</td>
<td>[Data base constant]</td>
</tr>
<tr>
<td>NUM_BANDS</td>
<td>[Data base constant]</td>
</tr>
<tr>
<td>PLATFORM_ALTITUDE</td>
<td>[Determined from latitude and longitude information provided in the NASA Ames flight summary reports]</td>
</tr>
<tr>
<td>MIN_SOLAR_ZEN_ANG</td>
<td>[Calculated with software from latitude and longitude and time information]</td>
</tr>
<tr>
<td>MAX_SOLAR_ZEN_ANG</td>
<td>[Calculated with software from latitude and longitude and time information]</td>
</tr>
<tr>
<td>MIN_SOLAR_AZ_ANG</td>
<td>[Calculated with software from latitude and longitude and time information]</td>
</tr>
<tr>
<td>MAX_SOLAR_AZ_ANG</td>
<td>[Calculated with software from latitude and longitude and time information]</td>
</tr>
<tr>
<td>C130_MISSION_ID</td>
<td>[Taken from the delivered tape label and the NASA Ames Flight Summary Reports]</td>
</tr>
<tr>
<td>C130_LINE_NUM</td>
<td>[Taken from the delivered tape label and the NASA Ames Flight Summary Reports]</td>
</tr>
<tr>
<td>C130_RUN_NUM</td>
<td>[Taken from the delivered tape label and the NASA Ames Flight Summary Reports]</td>
</tr>
<tr>
<td>C130_SITE</td>
<td>[Taken from the delivered tape label and the NASA Ames Flight Summary Reports]</td>
</tr>
<tr>
<td>BAND_QUALITY</td>
<td>[Constant software parameter value]</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>[Constant software parameter value]</td>
</tr>
<tr>
<td>NS001_MEAN_FRAME_STATUS</td>
<td>[Software derived from NS001 housekeeping data]</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>[Calculated with software from the C130 altitude and heading, starting and ending flight line latitude and longitude, and the static NS001 scan angle information]</td>
</tr>
<tr>
<td>NW_LONGITUDE</td>
<td>[Calculated with software from the C130 altitude and heading, starting and ending flight line latitude and longitude, and the static NS001 scan angle information]</td>
</tr>
<tr>
<td>NE_LATITUDE</td>
<td>[Calculated with software from the C130 altitude and heading, starting and ending flight line latitude and longitude, and the static NS001 scan angle information]</td>
</tr>
<tr>
<td>NE_LONGITUDE</td>
<td>[Calculated with software from the C130 altitude and heading, starting and ending flight line latitude and longitude, and the static NS001 scan angle information]</td>
</tr>
</tbody>
</table>
7.3.5 Data Range

The maximum range of DNs in each level-0 NS001 image band is limited from 0 (zero) to 255 so that the values can be stored in a single 8-bit (1-byte) field. The following table gives information about the parameter values found in the inventory table on the CD-ROM.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
<th>Missing Data Value</th>
<th>Unrel Data Value</th>
<th>Below Limit Data Value</th>
<th>Detect Data Value</th>
<th>Not Collected Data Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL_COVERAGE</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>16-APR-94</td>
<td>17-SEP-94</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>START_TIME</td>
<td>6</td>
<td>2343</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>END_TIME</td>
<td>6</td>
<td>2237</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>PLATFORM</td>
<td>C130</td>
<td>C130</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>INSTRUMENT</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NUM_BANDS</td>
<td>8</td>
<td>8</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>PLATFORM_ALTITUDE</td>
<td>106</td>
<td>8025</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MIN_SOLAR_ZEN_ANGLE</td>
<td>32.3</td>
<td>64.8</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MAX_SOLAR_ZEN_ANGLE</td>
<td>33.3</td>
<td>71.3</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MIN_SOLAR_AZ_ANGLE</td>
<td>92.9</td>
<td>274.3</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MAX_SOLAR_AZ_ANGLE</td>
<td>94.1</td>
<td>283.1</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>C130_MISSION_ID</td>
<td>94-004-09</td>
<td>94-009-09</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>C130_LINE_NUM</td>
<td>1</td>
<td>703</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>C130_RUN_NUM</td>
<td>1</td>
<td>3</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>C130_SITE</td>
<td>429</td>
<td>433</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>BAND_QUALITY</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NS001_MEAN_FRAME_STATUS</td>
<td>0</td>
<td>40</td>
<td>None</td>
<td>None</td>
<td>-99</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>53.02807</td>
<td>56.3363</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NW_LONGITUDE</td>
<td>-106.53493</td>
<td>-97.90026</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NE_LATITUDE</td>
<td>53.02709</td>
<td>56.09363</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NE_LONGITUDE</td>
<td>-106.23253</td>
<td>-97.65146</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SW_LATITUDE</td>
<td>53.00191</td>
<td>56.0027</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SW_LONGITUDE</td>
<td>-106.61522</td>
<td>-97.96021</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
Minimum Data Value - The minimum value found in the column.
Maximum Data Value - The maximum value found in the column.
Missing Data Value - The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.
Unreliable Data Value - The value that indicates unreliable data. This is used to indicate that an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.
Below Detect Limit - The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Collected - This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.
Blank -- Indicates that a blank spaces are used to denote that type of value.
N/A -- Indicates that the value is not applicable to the respective column.
None -- Indicates that no values of that sort were found in the column.

7.4 Sample Data Record
A sample data record for the level-0 NS001 images is not available here. The following are wrapped versions of the first few records from the level-0 NS001 inventory table on the CD-ROM:

'SSA-9OA', 16-APR-94, 1606, 1606, 'C130', 'NS001', 8, 4754.0, 56.1, 56.3, 123.5, 123.8, '94-004-09', 301, 1, '429', 'NOT ASSESSED', 'NOT ASSESSED', 0.0, 53.68983, -106.33041, 53.67367, -105.94092, 53.53624, -106.34776, 53.52015, -105.9597, 'PRE'
'SSA-9OA', 16-APR-94, 1606, 1610, 'C130', 'NS001', 8, 4754.0, 55.8, 56.1, 123.8, 124.6, '94-004-09', 301, 1, '429', 'NOT ASSESSED', 'NOT ASSESSED', 0.0, 53.68983, -106.33041, 53.67346, -105.93592, 53.53646, -106.34773, 53.52015, -105.9547, 'PRE'

8. Data Organization

8.1 Data Granularity
The smallest unit of data for level-0 NS001 images is a single image. Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-0 NS001 images are not. See Section 15 for information about how to obtain the data.
8.2 Data Format(s)

The CD-ROM inventory listing file consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

A level-0 NS001 image from BORIS is contained in a single file. Each record of a level-0 NS001 data file contains 6,000 bytes. The number of records in a file varies depending on the length of the flight line. Each physical record of 6,000 bytes contains eight logical records of 750 bytes. These sets of eight logical records contain the consecutive eight bands of NS001 data for a given image line in BIL format. Each logical record contains 50 bytes of housekeeping information, 699 bytes of image data, and 1 filler byte. The fields containing 16- or 32-bit (2- or 4-byte) values are stored as high-order byte first. For computer systems using low-order byte first ordering, the bytes in these fields need to be swapped before they can be interpreted properly. The specific logical record structure is:

<table>
<thead>
<tr>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-50</td>
<td>Channel Scanline Housekeeping Information</td>
</tr>
<tr>
<td>1 - 2</td>
<td>Data Frame Status</td>
</tr>
<tr>
<td>0</td>
<td>Good frame</td>
</tr>
<tr>
<td>10</td>
<td>Interpolated data</td>
</tr>
<tr>
<td>20</td>
<td>Repeated data</td>
</tr>
<tr>
<td>30</td>
<td>Zero-fill for data</td>
</tr>
<tr>
<td>3 - 4</td>
<td>Radiance Per Count Calibration Values</td>
</tr>
<tr>
<td></td>
<td>Visible channel (1-7) flight calibration values in units of tens (not tenths) of nanowatts per square centimeter per micron per steradian per count.</td>
</tr>
<tr>
<td></td>
<td>Thermal channel is not used.</td>
</tr>
<tr>
<td>5 - 8</td>
<td>Scanline Count (32-bit integer)</td>
</tr>
<tr>
<td>9 - 10</td>
<td>BB1 Thermistor Count</td>
</tr>
<tr>
<td>11 - 12</td>
<td>BB2 Thermistor Count</td>
</tr>
<tr>
<td>13 - 14</td>
<td>BB1 Thermal Reference Temperature in units of hundredths of degrees C</td>
</tr>
<tr>
<td>15 - 16</td>
<td>BB2 Thermal Reference Temperature in units of hundredths of degrees C</td>
</tr>
<tr>
<td>17 - 18</td>
<td>Scan Speed in units of hundredths of scans per second</td>
</tr>
<tr>
<td>19 - 20</td>
<td>GMT Hours</td>
</tr>
<tr>
<td>21 - 22</td>
<td>GMT Minutes</td>
</tr>
<tr>
<td>23 - 24</td>
<td>GMT Seconds in units of tenths of seconds</td>
</tr>
<tr>
<td>25 - 26</td>
<td>Demagnification Value (X 1000)</td>
</tr>
<tr>
<td>27 - 28</td>
<td>Total Air Temperature (TAT) in units of tenths of °C</td>
</tr>
<tr>
<td></td>
<td>TAT algorithm is TAT(°C)=0.483(16-bit value)-70.4</td>
</tr>
<tr>
<td>29 - 30</td>
<td>Gain Value (X 1000)</td>
</tr>
<tr>
<td></td>
<td>Visible channel (1-7) gain value is defined as 1000 times (REF LAMP RAD COUNT minus BB1 RAD COUNT) divided by (the laboratory value of reference lamp less tare).</td>
</tr>
<tr>
<td></td>
<td>Thermal channel (8) is not used.</td>
</tr>
<tr>
<td>31 - 32</td>
<td>Channel Number</td>
</tr>
<tr>
<td>33 - 36</td>
<td>Time (GMT) expressed as a 7-digit number HHMMSST</td>
</tr>
<tr>
<td>37 - 38</td>
<td>BB1 Radiance Count</td>
</tr>
<tr>
<td>39 - 40</td>
<td>BB2 Radiance Count</td>
</tr>
<tr>
<td>41 - 42</td>
<td>Reference Lamp Voltage Count</td>
</tr>
<tr>
<td>43 - 44</td>
<td>Reference Lamp Current Count</td>
</tr>
<tr>
<td>45 - 46</td>
<td>Reference Lamp State (16 bits 00000000ab000000)</td>
</tr>
</tbody>
</table>
a=1 means reference lamp selected as visible high-level calibration source
b=0 means lamp has degraded below predetermined level of 12.8V
b=1 means lamp has not degraded below predetermined level (i.e., a value of 192 (= 128 + 64) indicates a good lamp state

47 - 48 Reference Lamp Radiance Count
49 - 50 Precision Radiation Thermometer (PRT-5) in units of tenths of °C (-40.0 to +70.0 °F)
(memo 21-Feb-1985)

51 - 749 Digitized Video Pixel Information (see note below)
51 Digitized Video Pixel #699; Image Pixel #1
52 Digitized Video Pixel #698; Image Pixel #2
53 Digitized Video Pixel #697; Image Pixel #3
54 Digitized Video Pixel #696; Image Pixel #4
...
749 Digitized Video Pixel #1; Image Pixel #699
750 Filler Byte

NOTE: Based on the scanning direction of the NS001 instrument (right to left or clockwise) and how it is mounted in the C-130 aircraft, the first ground area imaged is to the far left of the aircraft’s direction of travel. This pixel in a given scan line is labeled as Video Pixel #1, and the last ground area imaged (to the far right of the aircraft's direction of travel) is labeled as Video Pixel #699. This set of video pixels is reversed in order when they are written to the level-0 tape file records so that the pixels are in the correct spatial position when read by the user.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms
None.

9.2 Data Processing Sequence

9.2.1 Processing Steps
BORIS staff processed the level-0 NS001 imagery by:
- Extracting pertinent header and calibration information from the level-0 image product and writing it to a disk file
- Reading the information in the disk file and loading the online data base with needed information

9.2.2 Processing Changes
None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
None.

9.3.2 Calculated Variables
None.
9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error
The NS001 data are calibrated in-flight by reference to the NS001 internal integrating sphere source. Apparent instabilities in this source or its monitoring circuitry, which are not fully understood, are the principal limiting factors in the absolute calibration of NS001 data. Uncertainties caused solely by this behavior reached 25% in 1987, though more typically they are expected to be less than 15%. Other identified error sources at the 1-2% level for typical signals include dark current drift along the scan line, hysteresis-like sensitivity changes along the scan line, random noise, scan-speed-induced errors, and nonlinearity of radiance with wavelength.

Channel 7 (2.08-2.35 μm) shows a number of peculiarities that are hysteresis-like, including a change in the apparent dark current drift along scan with scene brightness and a drop in sensitivity in scanning across a bright target of an estimated 8% over the total 100-degree scan angle. Polarization sensitivity of the NS001 was such that for typical atmospheric conditions, errors in channel 1 (0.45-0.52 μm) radiances would be up to +/-10% and vary with scan angle; this progressively decreases with increasing wavelength (Markham and Ahmad, 1992).

10.2 Quality Assessment

10.2.1 Data Validation by Source
Spectral errors could arise from image-wide signal-to-noise ratio, saturation, cross-talk, spikes, and response normalization caused by a change in gain.

10.2.2 Confidence Level/Accuracy Judgment
System optical focus is continually monitored by close observation of the apparent sharpness and resolution of objects appearing in scenes after data processing. Although this is somewhat subjective, the approach has proved to be a viable alternative compared to the classical resolution measurement method.

The latter method requires removing the scanner system from the C-130 airplane with subsequent setup. This is not a practical option during the flying/deployment portion of the year. However, any observed focus degradation would be corrected by focus adjustment.

10.2.3 Measurement Error for Parameters
The NE spectral radiance for the channels ranges from 0.08 to 2.77 microwatts per square cm. Uncertainties caused by the behavior of the internal integrating sphere reached 25% in 1987, though more typically they are expected to be less than 15%.

10.2.4 Additional Quality Assessments
None.

10.2.5 Data Verification by Data Center
None, other than reviewing the values extracted from the tape files and loaded in the data base.
11. Notes

11.1 Limitations of the Data
To date, the following discrepancies/problems have been noted in the data:

- Certain values in the header information, such as MEAN FRAME STATUS, MEAN and STDV GSFC, and AMES GAIN and OFFSETS, especially for bands 7 and 8, were outside the valid range for these parameters. Such values, when found, were entered into the BORIS data base as the number -99.0 or -999.0, depending on the data base field width. The problem appears to occur at random.

11.2 Known Problems with the Data
None.

11.3 Usage Guidance
The NS001 data are not geometrically corrected. The data contain both panoramic distortion, as a function of the 100-degree total FOV, as well as other spatial perturbations induced by a moving aircraft.

11.4 Other Relevant Information
Two in-flight adjustments are made that affect the radiometric calibration of the reflective channels. The primary adjustment is to the postamplifier gain of each channel. This is adjusted with a channel-specific potentiometer before and between data acquisitions to optimize the spread of the data across the range of the A/D converter (8 bits). The gain settings are continuously variable and are not directly recorded in the data; they are inferred from changes in the instrument response to the integrating sphere. The second adjustment is for scan speed, which is adjusted between 10 and 85 scans per second to maintain contiguous scan lines, or some multiple of contiguous lines if contiguity is not maintainable at the altitude required for data collection. Typical altitudes for BOREAS in 1994 were 5,000 m, which produced 12.5-m pixels at nadir given the NS001’s 2.5-mrad IFOV.

Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-0 NS001 images are not. See Section 15 for information about how to acquire the actual level-0 NS001 images.

12. Application of the Data Set
These data can be used to supplement the Landsat TM coverage of the BOREAS areas during 1994 for high-resolution mapping of the ground surface.

13. Future Modifications and Plans
None. The NS001 instrument was decommissioned in October 1995.

14. Software

14.1 Software Description
BORIS staff developed software and command procedures for:

- Extracting header information from level-0 NS001 TMS images on tape and writing it to ASCII files on disk
- Reading the ASCII disk file and logging the level-0 NS001 image products into the Oracle data base tables
14.2 Software Access
The software is written in C and is operational on VAX 6410 and MicroVAX 3100 systems at GSFC. The primary dependencies in the software are the tape I/O library and the Oracle data base utility routines.

15. Data Access
The level-0 NS001 TMS images are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information
For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification
Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics

15.3 Procedures for Obtaining Data
Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans
The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products
The BOREAS level-0 NS001 TMS data can be made available on 8-mm, Digital Archive Tape (DAT), or 9-track tapes at 1600 or 6250 Bytes Per Inch (BPI).

16.2 Film Products
Color aerial photographs and video records were made during data collection. The video record includes aircraft crew cabin intercom conversations and an audible tone that was initiated each time the sensor was triggered. The BOREAS data base contains an inventory of available BOREAS aircraft flight documentation, such as flight logs, videotapes, and photographs.
16.3 Other Products

Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-0 NS001 images are not. See Section 15 for information about how to obtain the data.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation


17.2 Journal Articles and Study Reports


17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms
None.

19. List of Acronyms

ARC - Ames Research Center
ASAS - Advanced Solid-State Array Spectroradiometer
ASCII - American Standard Code for Information Interchange
BIL - Band Interleaved by Line
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
BPI - Bytes Per Inch
CCRS - Canada Centre for Remote Sensing
CCT - Computer Compatible Tape
CD-ROM - Compact Disk-Read-Only Memory
DAAC - Distributed Active Archive Center
DAT - Digital Archive Tape
DN - Digital Number
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
ERTS - Earth Resources Technology Satellite
FFC-T - Focused Field Campaign - Thaw
FIFE - First ISLSCP Field Experiment
FOV - Field-of-View
fPAR - fraction of Photosynthetically Active Radiation
GICS - Geocoded Image Correction System
GIS - Geographic Information System
GMT - Greenwich Mean Time
GSFC - Goddard Space Flight Center
IFC - Intensive Field Campaign
20. Document Information

20.1 Document Revision Date(s)
Written: 09-Jun-1995
Last Updated: 05-Feb-1999

20.2 Document Review Date(s)
BORIS Review: 03-Jan-1997
Science Review: 09-May-1997

20.3 Document ID

20.4 Citation
When using these data, please include the following acknowledgement as well as citations of relevent papers in Section 17.2: The BOREAS Level-0 NS001 TMS data were collected and processed from the original aircraft tapes by personnel of the Medium Altitude Aircraft Branch at NASA ARC. Their contributions to providing this data set are greatly appreciated.

Also, cite the BOREAS CD-ROM set as:

20.5 Document Curator
Unknown.

20.6 Document URL
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

BOREAS Level-0 NS001 TMS Imagery: Digital Counts in BIL Format

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R. Dominguez: ATAC, Inc., NASA Ames Research Center, Moffett Field, California

Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information,
7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

For BOREAS, the NS001 TMS imagery, along with the other remotely sensed images, was collected in order to provide spatially extensive information over the primary study areas. This information includes detailed land cover and biophysical parameter maps such as fPAR and LAI. Data collections occurred over the study areas during the 1994 field campaigns.

BOREAS, remote sensing science, NS001 TMS imagery.