



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

Forrest G. Hall, Editor

Volume 81

BOREAS Level-0 AOCI Imagery: Digital Counts in BIL Format

*Jeffrey A. Newcomer, Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland
Roseanne Dominguez, ATAC, Inc., NASA Ames Research Center, Moffett Field, California*

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

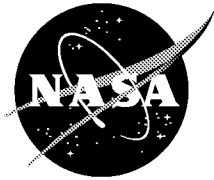
The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- **TECHNICAL PUBLICATION.** Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.
- **TECHNICAL MEMORANDUM.** Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- **CONTRACTOR REPORT.** Scientific and technical findings by NASA-sponsored contractors and grantees.
- **CONFERENCE PUBLICATION.** Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.
- **SPECIAL PUBLICATION.** Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.
- **TECHNICAL TRANSLATION.** English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results . . . even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at <http://www.sti.nasa.gov/STI-homepage.html>
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA Access Help Desk at (301) 621-0134
- Telephone the NASA Access Help Desk at (301) 621-0390
- Write to:
NASA Access Help Desk
NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320



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

Forrest G. Hall, Editor

Volume 81

BOREAS Level-0 AOCI Imagery: Digital Counts in BIL Format

*Jeffrey A. Newcomer, Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland
Roseanne Dominguez, ATAC, Inc., NASA Ames Research Center, Moffett Field, California*

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320
Price Code: A17

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Price Code: A10

BOREAS Level-0 AOCI Imagery: Digital Counts in BIL Format

Jeffrey A. Newcomer, Roseanne Dominguez

Summary

The level-0 AOCI imagery, along with the other remotely sensed images, was collected to provide spatially extensive information about radiant energy over the primary BOREAS study areas. The AOCI was the only remote sensing instrument flown with wavelength bands specific to the investigation of various aquatic parameters such as chlorophyll content and turbidity. Only one flight of the AOCI instrument was made onboard the ER-2 aircraft on 21-Jul-1994 over the SSA.

Note that the level-0 AOCI 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 AOCI images.

Table of Contents

- 1) Data Set Overview
- 2) Investigator(s)
- 3) Theory of Measurements
- 4) Equipment
- 5) Data Acquisition Methods
- 6) Observations
- 7) Data Description
- 8) Data Organization
- 9) Data Manipulations
- 10) Errors
- 11) Notes
- 12) Application of the Data Set
- 13) Future Modifications and Plans
- 14) Software
- 15) Data Access
- 16) Output Products and Availability
- 17) References
- 18) Glossary of Terms
- 19) List of Acronyms
- 20) Document Information

1. Data Set Overview

1.1 Data Set Identification

BOREAS Level-0 AOCI Imagery: Digital Counts in BIL Format

1.2 Data Set Introduction

The level-0 Airborne Ocean Color Imager (AOCI) images contain 10 spectral bands that cover portions of the electromagnetic spectrum from the visible through the thermal infrared. The data are provided in the format that they were delivered to the BOREal Ecosystem-Atmosphere Study (BOREAS) Information System (BORIS).

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 10-band AOCI image data collected on the National Aeronautics and Space Administration's (NASA's) ER-2 aircraft.

For BOREAS, the AOCI 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, biophysical parameter maps such as fraction of Photosynthetically Active Radiation (fPAR), and Leaf Area Index (LAI), and surface thermal properties. The AOCI was the only remote sensing instrument flown with wavelength bands specific to the investigation of various aquatic parameters such as chlorophyll content and turbidity.

1.4 Summary of Parameters

AOCI level-0 image data in BORIS contain the following parameters: original housekeeping and calibration information and bands 1 to 10 in the NASA Ames Research Center (ARC) Band Interleaved by Line (BIL) format.

1.5 Discussion

BORIS staff processed the AOCI 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 ER-2 Aerial Photography

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

BOREAS RSS-18 Level-1B AVIRIS Imagery: At-sensor Radiance in BIL 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:

Jeffrey S. Myers
Aircraft Data and Sensor Facilities
NASA Ames Research Center
MS 240-6 (Bldg. 240, Rm. 219)
Moffett Field, CA 94035-1000
(415) 604-6253
(415) 604-4987 (fax)
jmyers@msmail.arc.nasa.gov

Contact 2:

Jeffrey A. Newcomer
Raytheon ITSS
Code 923
NASA GSFC
Greenbelt, MD 20771
(301) 286-7858
(301) 286-0239 (fax)
Jeffrey.Newcomer@gsfc.nasa.gov

3. Theory of Measurements

The NASA Earth Resources Aircraft Program at ARC operates the ER-2 aircraft to acquire data for Earth science research. The AOCI instrument used on the ER-2 aircraft collects radiance measurements in 10 total spectral bands, with nine bands covering the visible and near-infrared spectrum from 0.436 to 1.054 micrometers (μm), and one thermal-infrared band covering 8.423 to 12.279 μm .

Thematic considerations have dictated, within technical constraints, the choice of spectral band position and width in the AOCI sensor. These bands were chosen after many years of analysis for their value in discrimination of aquatic features.

4. Equipment

4.1 Sensor/Instrument Description

The AOCI instrument was designed to gather information about the visible reflectance and temperature characteristics of water bodies. The AOCI is generally flown at high altitudes and provides 49.5-m resolution at nadir at an altitude of 19,800 m. The AOCI is flown aboard NASA's ER-2 aircraft based at ARC.

The 10 spectral channels of the AOCI sensor have the following bandpasses:

AOCI Channel	Wavelength, μm
1	0.436 - 0.455
2	0.481 - 0.501
3	0.511 - 0.531
4	0.554 - 0.575
5	0.610 - 0.631
6	0.655 - 0.676
7	0.741 - 0.800
8	0.831 - 0.897
9	0.989 - 1.054
10	8.423 - 12.279

4.1.1 Collection Environment

As part of the BOREAS Staff Science Data Collection Program, BORIS distributed 10-band level-0 AOCI image data. The AOCI was flown on NASA's ER-2 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 ER-2 Experimenter's Handbook (supplemental) produced by the High Altitude Missions Branch at ARC provides a description of the instrument, calibration procedures, and data format.

4.1.2 Source/Platform

NASA's ER-2 Earth Resources Aircraft

4.1.3 Source/Platform Mission Objectives

The AOCI is a multispectral scanner built by Daedalus Enterprises, designed for oceanographic remote sensing. The response of the instrument is optimized for the low levels of radiance normally associated with water scenes, so some bands may saturate over bright terrestrial targets.

4.1.4 Key Variables

Emitted radiation, reflected radiation, and temperature.

4.1.5 Principles of Operation

None given.

4.1.6 Sensor/Instrument Measurement Geometry

Instantaneous Field-Of-View (IFOV)	2.5 mrad
Total Scan Angle	85 degrees
Pixels/Scan Line	716

Sensor footprint is 49.5 x 49.5 m at nadir at 19,800-m altitude.

4.1.7 Manufacturer of Sensor/Instrument

Daedalus Enterprises
Ann Arbor, MI

4.2 Calibration

4.2.1 Specifications

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

AOCI Channel	Wavelength, μm
1	0.436 - 0.455
2	0.481 - 0.501
3	0.511 - 0.531
4	0.554 - 0.575
5	0.610 - 0.631
6	0.655 - 0.676
7	0.741 - 0.800
8	0.831 - 0.897
9	0.989 - 1.054
10	8.423 - 12.279

DESIGN DATA:

IFOV	2.5 milliradians
Across-track FOV	+/- 42.5°
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 ability	One-third of the IFOV, scan line to scan line

Data quantization	10-bits (1,024 discrete levels) for bands 1 to 8 and 8-bits (256 discrete levels) for bands 9 and 10
Number of video samples/scan line	716
Roll compensation	+/-15°
Scan mirror	45° rotating mirror

4.2.1.1 Tolerance

Unknown.

4.2.2 Frequency of Calibration

The ARC Sensor Calibration Laboratory measures the Spectral Response Function (SRF) of each band several times per year using a full-aperture scanning monochromator. Radiometric calibration is regularly performed using a low-intensity 30-in. integrating sphere with a 12-in. exit aperture. The sphere is calibrated periodically against a National Institute of Standards and Technology (NIST) standard reference source. The SRF is then convolved with the measured sphere radiance to produce in-band radiance for bands 1-9. The thermal-infrared band 10 is calibrated with the two onboard blackbody reference sources that are viewed before and after each scan line during the data acquisition, together with the SRF measured in the laboratory.

4.2.3 Other Calibration Information

AOCI 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 as a "demagnification factor."

5. Data Acquisition Methods

As part of the BOREAS Staff Science Data Collection Program, BORIS distributed 10-band level-0 AOCI image data. The AOCI was flown on NASA's ER-2 aircraft during BOREAS (see the BOREAS Experiment Plan for flight pattern details and objectives).

Maintenance and operation of the instrument are the responsibility of ARC. The ER-2 Experimenter's Handbook (supplemental) produced by the HIGH Altitude Missions Branch at ARC provides a description of the instrument, calibration procedures, and data format.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

The BOREAS level-0 AOCI images cover the Southern Study Area (SSA), which is located in the southwest portion of the overall BOREAS region.

7.1.1 Spatial Coverage

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

	Latitude	Longitude
	-----	-----
Northwest	54.321 N	106.228 W
Northeast	54.225 N	104.237 W
Southwest	53.515 N	106.321 W
Southeast	53.420 N	104.368 W

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The AOCI IFOV provides a footprint of 49.5 m at nadir at an altitude of 19,800 m, which was typical of the BOREAS flight.

7.1.4 Projection

The BOREAS level-0 AOCI 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 AOCI 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 level-0 AOCI image data were collected during Intensive Field Campaign (IFC)-2 on 21-Jul-1994.

7.2.2 Temporal Coverage Map

IFC#	Dates
-----	-----
IFC-2	21-Jul-1994

7.2.3 Temporal Resolution

Images were acquired only on 21-Jul-1994.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameter contained in the image data files is: Digital Number (DN)

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

Column Name
SPATIAL_COVERAGE
DATE_OBS
START_TIME
END_TIME
PLATFORM
INSTRUMENT
NUM_BANDS
PLATFORM_ALTITUDE
MIN_SOLAR_ZEN_ANG
MAX_SOLAR_ZEN_ANG
MIN_SOLAR_AZ_ANG
MAX_SOLAR_AZ_ANG
ER2_MISSION_ID
BAND_QUALITY
CLOUD_COVER
AOCI_MEAN_FRAME_STATUS
NW_LATITUDE
NW_LONGITUDE
NE_LATITUDE
NE_LONGITUDE
SW_LATITUDE
SW_LONGITUDE
SE_LATITUDE
SE_LONGITUDE
CRTFCN_CODE

7.3.2 Variable Description/Definition

For the image data files:

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

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

Column Name	Description
SPATIAL_COVERAGE	The general term used to denote the spatial area over which the data were collected.
DATE_OBS	The date on which the data were collected.
START_TIME	The starting Greenwich Mean Time (GMT) for the data collected.
END_TIME	The ending Greenwich Mean Time (GMT) for the data collected.
PLATFORM	The object (e.g., satellite, aircraft, tower, person) that supported the instrument.
INSTRUMENT	The name of the device used to make the measurements.
NUM_BANDS	The number of spectral bands in the data.

PLATFORM_ALTITUDE	The nominal altitude of the data collection platform above the target.
MIN_SOLAR_ZEN_ANG	The minimum angle from the surface normal (straight up) to the sun during the data collection.
MAX_SOLAR_ZEN_ANG	The maximum angle from the surface normal (straight up) to the sun during the data collection.
MIN_SOLAR_AZ_ANG	The minimum azimuthal direction of the sun during data collection expressed in clockwise increments from North.
MAX_SOLAR_AZ_ANG	The maximum azimuthal direction of the sun during data collection expressed in clockwise increments from North.
ER2_MISSION_ID	The mission identifier assigned to the ER2 mission in the form of YY-DDD where YY is the last two digits of the fiscal year, and DDD is the deployment number. An example would be 94-120.
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.
AOCI_MEAN_FRAME_STATUS	The mean frame status calculated from the respective values on the digital tape of AOCI data collected during the given flight.
NW_LATITUDE	The NAD83 based latitude coordinate of the north west 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 southwest corner of the minimum bounding rectangle for the data.
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:

Column Name	Units
SPATIAL_COVERAGE	[none]
DATE_OBS	[DD-MON-YY]
START_TIME	[HHMM GMT]
END_TIME	[HHMM GMT]
PLATFORM	[none]
INSTRUMENT	[none]
NUM_BANDS	[counts]
PLATFORM_ALTITUDE	[meters]
MIN_SOLAR_ZEN_ANG	[degrees]
MAX_SOLAR_ZEN_ANG	[degrees]
MIN_SOLAR_AZ_ANG	[degrees]
MAX_SOLAR_AZ_ANG	[degrees]
ER2_MISSION_ID	[none]
BAND_QUALITY	[none]
CLOUD_COVER	[none]
AOCI_MEAN_FRAME_STATUS	[unitless]
NW_LATITUDE	[degrees]
NW_LONGITUDE	[degrees]
NE_LATITUDE	[degrees]
NE_LONGITUDE	[degrees]
SW_LATITUDE	[degrees]
SW_LONGITUDE	[degrees]
SE_LATITUDE	[degrees]
SE_LONGITUDE	[degrees]
CRTFCN_CODE	[none]

7.3.4 Data Source

The level-0 AOCI image bands were collected by the AOCI instrument on the ER2 aircraft. The raw data were decommutated, processed, and sent to BORIS by personnel within the High Altitude Aircraft Branch at NASA ARC.

The source of the parameter values contained in the inventory listing file on the CD-ROM are:

Column Name	Data Source
SPATIAL_COVERAGE	[ER2 Flight Summary Reports and calculations within the BORIS software using information from the AOCI image data]
DATE_OBS	[AOCI image housekeeping data]
START_TIME	[AOCI image housekeeping data]
END_TIME	[AOCI image housekeeping data]
PLATFORM	[Constant software parameter value]
INSTRUMENT	[Constant software parameter value]
NUM_BANDS	[Constant software parameter value]
PLATFORM_ALTITUDE	[ER2 Flight Summary Reports]
MIN_SOLAR_ZEN_ANG	[Calculated from DATE_OBS, TIME_OBS, and latitude and longitude information]
MAX_SOLAR_ZEN_ANG	[Calculated from DATE_OBS, TIME_OBS, and

	latitude and longitude information]
MIN_SOLAR_AZ_ANG	[Calculated from DATE_OBS, TIME_OBS, and latitude and longitude information]
MAX_SOLAR_AZ_ANG	[Calculated from DATE_OBS, TIME_OBS, and latitude and longitude information]
ER2_MISSION_ID	[ER2 Flight Summary Reports]
BAND_QUALITY	[Constant software parameter value]
CLOUD_COVER	[Constant software parameter value]
AOCI_MEAN_FRAME_STATUS	[Calculated with software from the AOCI image housekeeping data]
NW_LATITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
NW_LONGITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
NE_LATITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
NE_LONGITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
SW_LATITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
SW_LONGITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
SE_LATITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
SE_LONGITUDE	[Calculated from the nadir latitude and longitude, heading, and altitude information in the Flight Summary Report, the constant instrument scan angle, and mean aircraft roll angle calculated from the image housekeeping data]
CRTFCN_CODE	[Constant data base value]

7.3.5 Data Range

The maximum range of DNs in each level-0 AOCI image band is limited from 0 to 1023 (10 bits) and is stored in a 16-bit (2-byte) field.

The following table gives information about the parameter values found in the inventory table on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SPATIAL_COVERAGE	N/A	N/A	None	None	None	None
DATE_OBS	21-JUL-94	21-JUL-94	None	None	None	None
START_TIME	1628	1854	None	None	None	None
END_TIME	1631	1903	None	None	None	None
PLATFORM	ER2	ER2	None	None	None	None
INSTRUMENT	N/A	N/A	None	None	None	None
NUM_BANDS	10	10	None	None	None	None
PLATFORM_ALTITUDE	19141	19903	None	None	None	None
MIN_SOLAR_ZEN_ANG	68.4	69.9	None	None	None	None
MAX_SOLAR_ZEN_ANG	68.7	70.7	None	None	None	None
MIN_SOLAR_AZ_ANG	275.6	277.7	None	None	None	None
MAX_SOLAR_AZ_ANG	276.2	278.9	None	None	None	None
ER2_MISSION_ID	94-120	94-120	None	None	None	None
BAND_QUALITY	N/A	N/A	None	None	None	None
CLOUD_COVER	N/A	N/A	None	None	None	None
AOCI_MEAN_FRAME_	0	0	None	None	None	None
STATUS						
NW_LATITUDE	53.333	54.46046	None	None	None	None
NW_LONGITUDE	-106.687	-104.83885	None	None	None	None
NE_LATITUDE	53.30691	54.43288	None	None	None	None
NE_LONGITUDE	-105.91003	-104.17147	None	None	None	None
SW_LATITUDE	53.00647	53.81953	None	None	None	None
SW_LONGITUDE	-106.73624	-104.92877	None	None	None	None
SE_LATITUDE	52.98057	53.78488	None	None	None	None
SE_LONGITUDE	-106.01627	-104.23941	None	None	None	None
CRTFCN_CODE	PRE	PRE	None	None	None	None

Minimum Data Value -- The minimum value found in the column.

Maximum Data Value -- The maximum value found in the column.

Missng 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.

Unrel Data Value -- The value that indicates unreliable data. This is used to indicate 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 Cllctd -- 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 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 AOCI images is not available here.

The following are wrapped versions of the first few records from the level-0 AOCI inventory table on the CD-ROM:

```
SPATIAL_COVERAGE, DATE_OBS, START_TIME, END_TIME, PLATFORM, INSTRUMENT, NUM_BANDS,
PLATFORM_ALTITUDE, MIN_SOLAR_ZEN_ANG, MAX_SOLAR_ZEN_ANG, MIN_SOLAR_AZ_ANG,
MAX_SOLAR_AZ_ANG, ER2_MISSION_ID, BAND_QUALITY, CLOUD_COVER, AOCI_MEAN_FRAME_STATUS,
NW_LATITUDE, NW_LONGITUDE, NE_LATITUDE, NE_LONGITUDE, SW_LATITUDE, SW_LONGITUDE,
SE_LATITUDE, SE_LONGITUDE, CRTFCN_CODE
'SSA', 21-JUL-94, 1628, 1631, 'ER2', 'AOCI', 10, 19202.0, 68.4, 68.7, 275.6, 276.2, '94-120',
'NOT ASSESSED', 'NOT ASSESSED', 0, 53.333, -105.95442, 53.30691, -105.38564, 53.00647,
-105.99376, 52.98057, -105.42938, 'PRE'
'SSA', 21-JUL-94, 1637, 1638, 'ER2', 'AOCI', 10, 19263.0, 69.1, 69.4, 276.6, 277.1, '94-120',
'NOT ASSESSED', 'NOT ASSESSED', 0, 54.01666, -105.60672, 53.98428, -104.93893, 53.64976,
-105.65474, 53.61767, -104.99284, 'PRE'
```

8. Data Organization

8.1 Data Granularity

The smallest unit of level-0 AOCI data is the entire tape of data covering the flights on 21-Jul-1994. Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-0 AOCI images are not. See Section 15 for information about how to obtain the data.

8.2 Data Format(s)

A level-0 AOCI tape contains one header file followed by up to 50 files containing data from AOCI flight lines. For BOREAS, the single level-0 tape contains the header file followed by 15 image data files.

The header file contains one record of 9,192 bytes that contain a mixture of ASCII and binary values. The multibyte integer fields are stored as high-order byte first. The contents of the header record fields are:

Bytes	Description
1 - 80	Data Description (ASCII characters, e.g., 'AOCI (CANADA)')
81 - 90	Flight Number (ASCII characters, e.g., 92-120)
91 - 120	Data Collection Date (ASCII characters, e.g., 21-JULY-1994)
121 - 150	Data Decommutation Date (ASCII characters)
151 - 180	Archive Tape Creation Date (ASCII characters)
181 - 182	Aircraft Number (binary 16-bit integer, value of 708)
183 - 184	Scanner Type (ASCII characters, 'DA')
185 - 186	Reel Number (binary 16-bit integer)
187 - 188	Expected Number of Reels (binary 16-bit integer)
189 - 198	Filler bytes

199 - 200	Number of Channels Processed (binary 16-bit integer) (Erroneous value of 12 on the BOREAS tape; should be 10)
201 - 224	Channel numbers (binary 16-bit integers) (Erroneous values of 11 and 12 on BOREAS tape; should be 1 to 10)
225 - 236	Filler bytes
237 - 238	Mode used to specify flight line boundaries (ASCII characters) (AL = all data contained in one flight line) (SL = selected scan lines) (BOREAS tape) (GM = selected times)
239 - 240	Number of operator-specified flight line intervals (binary 16-bit integer) (15 for BOREAS tape)
241 - 244	Start of flight line interval number 1 (binary 32-bit integer)
245 - 248	Start of flight line interval number 2 (binary 32-bit integer)
.	.
437 - 440	Start of flight line interval number 50 (binary 32-bit integer)
441 - 444	End of flight line interval number 1 (binary 32-bit integer)
445 - 448	End of flight line interval number 2 (binary 32-bit integer)
.	.
637 - 640	End of flight line interval number 50 (binary 32-bit integer)
641 - 9192	Filler bytes

Each level-0 AOCI image from a given flight is contained in one tape file. A physical tape record of 14,820 bytes contains 10 logical records of 1,482 bytes which contain housekeeping information (50 bytes) and the image data (1,432 bytes) from the 10 AOCI spectral bands in BIL order. The bytes of the 16-bit and 32-bit values in the housekeeping information are ordered as high-order byte first. The detailed structure of each logical record is:

AOCI Logical Data Record Structure

Bytes 1 - 50 Housekeeping Information	
1 - 2	Data Frame Status (16-bit integer) 0 implies the data are good; nonzero implies they are bad. 10 Interpolated data 20 Repeated data 30 Zero fill data
3 - 4	Run Number (16-bit integer)
5 - 8	Scan line count (32-bit integer)
9 - 12	Panel Thumbwheel switches (32-bit integer) Consists of 8 digits in the form YYFFFJJJ where YY is the last two digits of the year (e.g., 94) FFF is flight number (e.g., 120) JJJ is day of the year (e.g., 202)
13 - 14	Blackbody #1 Thermal Reference Temperature (16-bit integer) (hundredths of degrees C)
15 - 16	Blackbody #2 Thermal Reference Temperature (16-bit integer) (hundredths of degrees C)
17 - 18	Scan Speed (16-bit integer) (tenths of scans per second)
19 - 20	Greenwich Mean Time (GMT) hours (16-bit integer)
21 - 22	Minutes of the hour (16-bit integer)
23 - 24	Tenths of seconds (16-bit integer)
25 - 26	Demagnification value * 100 (16-bit integer) (Set to 100 to indicate unity, i.e., no demagnification)

27 - 28	Filler (16-bit integer)
29 - 30	Gain Value (times 1000) (16-bit integer)
31 - 32	Channel Number (16-bit integer)
33 - 36	Time (32-bit integer) (7 digits in the form of hhmmss.t where hh is the hour, mm is the minutes, ss is the seconds, and t is the tenths of a second)
37 - 38	Blackbody #1 Response (16-bit integer) (Counts) (What the sensor sees when it looks at Blackbody #1)
39 - 40	Blackbody #2 Response (16-bit integer) (Counts) (What the sensor sees when it looks at Blackbody #2)
41 - 42	Aircraft Roll angle counts (16-bit integer) (0.03 degrees per count or 0.06 degrees per pixel) (Positive values indicate rotation of the aircraft in a clockwise direction when viewed from the front; negative values indicate counterclockwise rotation)
43 - 50	Filler bytes
Bytes 51 - 1482 Binary Image data	
51 - 52	Digital count for pixel #1 of the scan line (16-bit integer)
53 - 54	Image data for pixel #2 of the scan line (16-bit integer)
.	.
.	.
1481 - 1482	Image data for pixel #716 of the scan line (16-bit integer)

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.

9. Data Manipulations

9.1 Formulae

None.

9.1.1 Derivation Techniques and Algorithms

None.

9.2 Data Processing Sequence

9.2.1 Processing Steps

BORIS staff processed the level-0 AOCI imagery by:

- Creating duplicate copies of the original image data tapes
- Extracting information from the tape to ASCII files on disk
- Using the extracted ASCII disk file information to inventory the images by date and location in the online data base

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

None given.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Spectral errors could arise because of image-wide signal-to-noise ratio, saturation, cross-talk, spikes, or response normalization caused by a change in gain.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

BORIS staff reviewed the AOCI images through software that summarized the housekeeping information in the records of each flight line and histogrammed the image bands to gather minimum, maximum, mean, and standard deviation values, which were then reviewed before loading the information into the data base. No anomalous values were noted.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

To date, no discrepancies or problems have been noted in the data.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

The level-0 AOCI images could be used for studying land surface or water properties contained in the imaged areas.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

BORIS staff developed software and command procedures for:

- Extracting header information from level-0 AOCI images on tape and writing it to ASCII files on disk
- Reading the ASCII disk file and logging the level-0 AOCI 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 Goddard Space Flight Center (GSFC). The primary dependencies in the software are the tape input/output (I/O) library and the Oracle data base utility routines.

15. Data Access

The level-0 AOCI 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
<http://www-eosdis.ornl.gov/>.

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 AOCI 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

None.

16.3 Other Products

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

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Airborne Instrumentation Research Project - Flight Summary Report Series. 1994. NASA Ames Research Center. Airborne Missions and Applications Division, Moffett Field, California, 94035.

NASA. 1990. ER-2 Earth Resources Aircraft Experimenter's Handbook. National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California.

17.2 Journal Articles and Study Reports

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. *Bulletin of the American Meteorological Society*. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. *Journal of Geophysical Research* 102 (D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

AOCI	- Airborne Ocean Color Imager
ARC	- Ames Research Center
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
CCT	- Computer Compatible Tape
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
DAT	- Digital Archive Tape
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
FOV	- Field-Of-View
fPAR	- fraction of Photosynthetically Active Radiation
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
GSFC	- Goddard Space Flight Center
IFOV	- Instantaneous Field-of-View
I/O	- Input/Output
LAI	- Leaf Area Index
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NIST	- National Institute of Standards and Technology
NSA	- Northern Study Area
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
SRF	- Spectral Response Function
SSA	- Southern Study Area
µm	- micrometers
URL	- Uniform Resource Locator

20. Document Information

20.1 Document Revision Date

Written: 05-Nov-1996

Last Updated: 05-Feb-1999

20.2 Document Review Dates

BORIS Review: 20-May-1997

Science Review: 20-May-1997

20.3 Document ID

20.4 Citation

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

Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE September 2000	3. REPORT TYPE AND DATES COVERED Technical Memorandum	
4. TITLE AND SUBTITLE Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS) BOREAS Level-0 AOCI Imagery: Digital Counts in BIL Format			5. FUNDING NUMBERS 923 RTOP: 923-462-33-01	
6. AUTHOR(S) Jeffrey A. Newcomer and Roseanne Dominguez Forrest G. Hall, Editor				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES) Goddard Space Flight Center Greenbelt, Maryland 20771			8. PERFORMING ORGANIZATION REPORT NUMBER 2000-03136-0	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES) National Aeronautics and Space Administration Washington, DC 20546-0001			10. SPONSORING / MONITORING AGENCY REPORT NUMBER TM—2000—209891 Vol. 81	
11. SUPPLEMENTARY NOTES J.A. Newcomer: Raytheon ITSS, NASA Goddard Space Flight Center, Greenbelt, Maryland; R. Dominguez: ATAC, Inc., NASA Ames Research Center, Moffett Field, California				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Unclassified—Unlimited Subject Category: 43 Report available from the NASA Center for AeroSpace Information, 7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The level-0 AOCI imagery, along with the other remotely sensed images, was collected to provide spatially extensive information about radiant energy over the primary BOREAS study areas. The AOCI was the only remote sensing instrument flown with wavelength bands specific to the investigation of various aquatic parameters such as chlorophyll content and turbidity. Only one flight of the AOCI instrument was made onboard the ER-2 aircraft on 21-Jul-1994 over the SSA.				
14. SUBJECT TERMS BOREAS, remote sensing science, AOCI imagery.			15. NUMBER OF PAGES 19	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

