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

Forrest G. Hall, Editor

Volume 82
BOREAS Level-0 C-130 Aerial Photography

J.A. Newcomer and R. Dominguez

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS Level-0 C-130 Aerial Photography

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BOREAS Level-0 C-130 Aerial Photography

Jeffrey A. Newcomer, Roseanne Dominguez

Summary

For BOREAS, C-130 and other aerial photography was collected to provide finely detailed and spatially extensive documentation of the condition of the primary study sites. The NASA C-130 Earth Resources aircraft can accommodate two mapping cameras during flight, each of which can be fitted with 6- or 12-inch focal-length lenses and black-and-white, natural-color, or color-IR film, depending upon requirements. Both cameras were often in operation simultaneously, although sometimes only the lower resolution camera was deployed. When both cameras were in operation, the higher resolution camera was often used in a more limited fashion. The acquired photography covers the period of April to September 1994. The aerial photography was delivered as rolls of large format (9 x 9 inch) color transparency prints, with imagery from mulitiple missions (hundreds of prints) often contained within a single roll. A total of 1533 frames were collected from the C-130 platform for BOREAS in 1994. Note that the level-0 C130 transparencies are not contained on the BOREAS CD-ROM set. An inventory file is supplied on the CD-ROM to inform users of all the data that were collected.

Some photographic prints were made from the transparencies. In addition, BORIS staff digitized a subset of the tranparencies and stored the images in JPEG format. The CD-ROM set contains a small subset of the collected aerial photography that were the digitally scanned and stored as JPEG files for most tower and auxiliary sites in the NSA and SSA. See Section 15 for information about how to acquire additional imagery.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS Level-0 C-130 Aerial Photography

1.2 Data Set Introduction

The BOReal Ecosystem-Atmosphere Study (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 the digital images and aerial photography collected on the National Aeronautics and Space Administration's (NASA's) C-130 aircraft. The level-0 C-130 photography consists of both natural-color and color-infrared (IR) transparencies acquired during the C-130 flights over the BOREAS study areas during 1994.

1.3 Objective/Purpose

For BOREAS, the C-130 and other aerial photography were collected to provide finely detailed and spatially extensive visual documentation of the condition of the primary study sites.

1.4 Summary of Parameters

Level-0 C-130 aerial photography, at two scales and in both natural-color (400-700 nm) and color-IR (510-900 nm), was obtained by dual-camera systems during the 1994 BOREAS field season. The aerial photography was delivered as rolls of transparency film and each frame is approximately 8 inches x 8 inches.

The imagery over the Northern Study Area (NSA) and Southern Study Area (SSA) tower and auxiliary sites that were digitized by BOREAS Information System (BORIS) staff are stored in Joint Photographic Experts Group (JPEG) files.

1.5 Discussion

BOREAS Information System (BORIS) staff processed the level-0 C-130 aerial photography by:

- Reviewing the film on the rolls with the flight logs obtained from NASA Ames Research Center (ARC) to check for discrepancies in the number of frames and coverage
- Compiling the information into spreadsheets for loading into the online data base
- Loading the spreadsheet information into data base tables
- Cross-checking the photographic information against data collected by other instrument systems on the C-130 aircraft

BOREAS Information System (BORIS) staff processed the JPEG images by:

- Viewing rolls of film on a light table to identify good frames of site coverage. Extracting the frames of interest from the film rolls, noting the frame number, mission, and film type,
- Scanning the transparencies using a digital scanner,
- Replacing the scanned frames within the film rolls,
- Post-processing the imagery in Adobe Photoshop to a) orient the imagery with the edge closest to north at the top, b) cropping images to the edge of the frame, c) adjusting the images for brightness, contrast, and hue if necessary,
- Saving images in JPEG format with a quality level of 6.

1.6 Related Data Sets

BOREAS Level-0 ER-2 Aerial Photography
BOREAS Level-0 C-130 Navigation Data
BOREAS Level-0 NS001 TMS Imagery: Digital Counts in BIL Format
BOREAS Level-0 TIMS Imagery: At-sensor Radiance in BSQ Format
BOREAS Level-1b ASAS Imagery

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

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3. Theory of Measurements

The Earth Resources Aircraft Program at NASA's ARC operated the C-130 aircraft to acquire data for Earth science research. The aerial photographic cameras used on the C-130 are furnished with film, lenses, and filters needed to meet various photographic needs. For BOREAS, the aerial photography was obtained to help provide fine spatial resolution information about the various intensive measurement sites. Parameters used were derived from flight requests submitted by principal investigators. All C-130 photo acquisition was flown with 60% overlap in order to provide stereo coverage over the study area. Dual Zeiss cameras were flown onboard the C-130B. Color-IR photographs were acquired on every BOREAS mission. During the thaw and Intensive Field Campaign (IFC)-1, the higher resolution camera often obtained natural-color photographs.

4. Equipment

4.1 Sensor/Instrument Description
The cameras used on the C-130 included:

- Zeiss RMK A 15/23 (camera ID# 75) with a 6-inch focal length (153-mm) lens
- Zeiss RMK AR 30/23 (camera ID# 85) with a 12-inch focal length (305-mm) lens

These are metric mapping cameras manufactured in Germany. The actual dates of manufacture are unknown.

4.1.1 Collection Environment

As part of the BOREAS Staff Science data collection effort, the ARC Medium Altitude Aircraft Branch collected and processed color-IR and natural-color aerial photography to BOREAS level-0 products. The various camera systems were flown on NASA's C-130 aircraft during the BOREAS missions (see the BOREAS Experiment Plan for flight pattern details and objectives). Maintenance and operation of the cameras were 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 systems, calibration procedures, and format.

4.1.2 Source/Platform

NASA's C-130 Earth Resources Aircraft.

4.1.3 Source/Platform Mission Objectives

The purpose of the aerial photography was to provide detailed spatial resolution information about the sites over which numerous data sets were being collected.

4.1.4 Key Variables

Reflected radiation.

4.1.5 Principles of Operation

The C-130 cameras were manually started and stopped by a camera operator at the beginning and end of each flight line. Rates of frame acquisition were determined by the camera operator. Photographic frames were nominally acquired (exposed) at a rate that provided 60% overlap from frame to frame to ensure adequate stereo coverage of the ground scene. The cycle between frames was determined by the speed and altitude of the aircraft.

4.1.6 Sensor/Instrument Measurement Geometry

Although a few lower-level flights were made over specific targets, the majority of BOREAS C-130 flight altitudes ranged from 4,000- to 8,000-m Above Ground Level (AGL). In most cases, two cameras acquired photography simultaneously, one with a 153.16-mm focal-length lens and another with a 305.11-mm focal-length lens. This resulted in photography at scales ranging from 1:13,000 to 1:52,000. The following are the various lens, film, filter, and exposure combinations used throughout the season.

Camera	Focal Length	Film Type	Filter(s)	F-Stop
Zeiss-075	153.16 mm	Aerochrome IR 2443	Wratten 12	4
Zeiss-075	153.16 mm	Aerochrome IR 2443	Wratten 12	5.6
Zeiss-085	305.11 mm	Aerochrome MS 2448	None	5.6
Zeiss-085	305.11 mm	Aerochrome IR 2443	Wratten 12	5.6
Zeiss-085	305.11 mm	Aerochrome IR 2443	Wratten 12	4

4.1.7 Manufacturer of Sensor/Instrument

The C-130 cameras were manufactured by Zeiss in Germany. The dates of manufacture are unknown.

4.2 Calibration

All camera calibrations were performed by the U.S. Geological Survey (USGS) National Mapping Division's Optical Science Laboratory in Reston, VA. The most recent calibration of camera ID# 85 was 30-June-1981. Camera ID# 75 was most recently calibrated on 10-Dec-1976. No post-BOREAS calibration was performed.

4.2.1 Specifications

```
Camera:  Zeiss-075
Lens Field-of-View (FOV)      90°
F-stop                        4
Lens focal length             153.16 mm
Frame rate                    dependent on aircraft altitude and speed

Camera:  Zeiss-085
Lens FOV                      55°
F-Stop                        5.6
Lens focal length             305.11 mm
Frame rate                    dependent on aircraft altitude and speed
```

The wavelength ranges (in micrometers) of film/filter combinations used are:

Film	Filter	Effective Wavelength
Aerochrome IR 2443	Wratten 12	.0.510-0.900 micrometers
Aerochrome MS 2448	None	.0.400-0.700 micrometers

4.2.1.1 Tolerance

Not applicable.

4.2.2 Frequency of Calibration

To conform to USGS mapping standards, the camera system should be calibrated every 3 years. The cameras used for BOREAS missions have not been calibrated recently and do not conform to these standards. A complete calibration of a camera system would determine the following:

- Calibrated focal length
- Radial distortion of the image plane
- Resolving power from center to edge of field of the image plane
- Filter parallelism
- Filter antivignetting gradient density
- Shutter speed and efficiency
- Film platen flatness and identification
- Location of the corner and midside fiducials and point of symmetry with reference to the principal point of autocollimation
- X, Y fiducial coordinates
- Distances between fiducial marks and 90f condition angle measurements

4.2.3 Other Calibration Information

These cameras have not been calibrated since NASA moved its Earth Resources program and operations from Johnson Space Center to ARC in 1982.

5. Data Acquisition Methods

As part of the BOREAS Staff Science data collection effort, the ARC Medium Altitude Aircraft Branch collected and processed color-IR and natural-color aerial photography to BOREAS level-0 products. The various camera systems were 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 cameras 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 systems, calibration procedures, and format.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

Flight summary reports and verbal records on videotapes are available.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The BOREAS level-0 photographic images cover portions of the Southern and Northern Study Areas, as well as some imagery over 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 JPEG files on the CD-ROM cover only tower sites and some of the auxiliary sites within the study areas.

```
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

The NAD83 corner coordinates of the NSA are:

             Latitude     Longitude
             --------     ---------
Northwest    56.249 N      98.825 W
Northeast    56.083 N      97.234 W
Southwest    55.542 N      99.045 W
Southeast    55.379 N      97.489 W
```

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

Typical altitudes for BOREAS were around 5,000-m AGL. The scale of the photography depends on the altitude of the aircraft and the focal length of the lens attached to the camera.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The photographs were collected during BOREAS' three IFCs and the Focused Field Campaign-Thaw (FFC-T) covering the period from 16-Apr-1994 through 17-Sep-1994.

The JPEG images on the CD-ROM were mostly from imagery acquired during August and September, except for a few images in June.

7.2.2 Temporal Coverage Map

Images were acquired at the following range of dates for each campaign:

Campaign	Dates
FFC-T	16-Apr-1994 -- 20-Apr-1994
IFC-1	26-May-1994 -- 08-Jun-1994
IFC-2	21-Jul-1994 -- 08-Aug-1994
IFC-3	06-Sep-1994 -- 17-Sep-1994

7.2.3 Temporal Resolution

Images were acquired on the following dates from respective cameras. Low/high in the camera column refers to the resolution/scale of the imagery as a result of the focal length of the lens used. If both cameras were in use, the two numbers in the subsequent columns refer to the respective cameras.

Site	Date	Camera low/high	# of Frames low/high	Film low/high
Thaw				
SSA	16-Apr-94	both	25/24	IR/VIS
SSA	19-Apr-94	low	260	IR
NSA	20-Apr-94	low	200	IR
IFC-1				
SSA	26-May-94	both	25/41	IR/VIS
SSA	31-May-94	both	34/58	IR/VIS
SSA	01-Jun-94	both	21/37	IR/VIS
SSA	04-Jun-94	both	19/33	IR/VIS
SSA	06-Jun-94	both	19/27	IR/VIS
NSA	07-Jun-94	both	107/53	IR/VIS
NSA	08-Jun-94	both	6/10	IR/VIS
IFC-2				
SSA	21-Jul-94	both	136/61	IR/IR
SSA	23-Jul-94	both	10/16	IR/IR
SSA	24-Jul-94	both	19/36	IR/IR
NSA*	02-Aug-94	both	4/4	IR/IR
NSA	04-Aug-94	both	102/30	IR/IR
NSA	08-Aug-94	low	63	IR
IFC-3				
NSA	06-Sep-94	low	6	IR
NSA	08-Sep-94	both	10/8	IR/IR
SSA	13-Sep-94	high	43	IR
SSA	16-Sep-94	both	99/37	IR/IR
NSA	17-Sep-94	both	103/69	IR/IR

* Frames on this date were removed from the archive because of poor site conditions.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The actual photographs are natural-color or color-IR transparencies. The parameters contained in the inventory listing file on the CD-ROM are:

```
        Column Name
------------------------------
SPATIAL_COVERAGE
DATE_OBS
START_TIME
END_TIME
C130_START_LATITUDE
C130_START_LONGITUDE
C130_END_LATITUDE
C130_END_LONGITUDE
C130_MISSION_ID
C130_LINE_NUM
C130_RUN_NUM
C130_SITE
PLATFORM_TRACKING
PLATFORM_ALTITUDE
SENSOR_ID
FOCAL_LENGTH
FILM_TYPE
START_FRAME_NUM
END_FRAME_NUM
CLOUD_COVER
PHOTO_QUALITY
COMMENTS
```

7.3.2 Variable Description/Definition

An analog picture captured on transparency film depicting the ground area below the C-130 aircraft in natural or infrared color. 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.
C130_START_LATITUDE	The NAD83 based latitude coordinate at the start of a C130 flight line as given in the flight summary reports.
C130_START_LONGITUDE	The NAD83 based longitude coordinate at the start of a C130 flight line as given in the flight summary reports.
C130_END_LATITUDE	The NAD83 based latitude coordinate at the end of a C130 flight line as given in the flight summary reports.

C130_END_LONGITUDE	The NAD83 based longitude coordinate at the end of a C130 flight line as given in the flight summary reports.
C130_MISSION_ID	The mission identifier assigned to the C130 miss 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 mission identifier 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).
PLATFORM_TRACKING	The azimuthal direction in which the data collection platform was traveling while collecting the data expressed as degrees clockwise from North.
PLATFORM_ALTITUDE	The nominal altitude of the data collection platform above the target.
SENSOR_ID	The identifier given to the sensor/instrument that collected the data.
FOCAL_LENGTH	The focal length of the lens that was mounted on the camera during the time that the photography was acquired.
FILM_TYPE	The type of photographic film that was used to acquire the imagery. An example is AEROCHROME MS 2448.
START_FRAME_NUM	The starting frame number for this line and run of the flight.
END_FRAME_NUM	The ending frame number for this line and run of the flight.
CLOUD_COVER	The data analyst's assessment of the cloud cover that exists in the data.
PHOTO_QUALITY	The provided or assessed quality of the photograph(s).
COMMENTS	Descriptive information to clarify or enhance the understanding of the other entered data.

7.3.3 Unit of Measurement

There is no unit of measurement for the C-130 imagery. 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]
C130_START_LATITUDE	[degrees]
C130_START_LONGITUDE	[degrees]
C130_END_LATITUDE	[degrees]
C130_END_LONGITUDE	[degrees]
C130_MISSION_ID	[none]
C130_LINE_NUM	[none]
C130_RUN_NUM	[none]
C130_SITE	[none]
PLATFORM_TRACKING	[degrees]
PLATFORM_ALTITUDE	[meters]
SENSOR_ID	[none]
FOCAL_LENGTH	[millimeters]
FILM_TYPE	[none]
START_FRAME_NUM	[unitless]
END_FRAME_NUM	[unitless]
CLOUD_COVER	[none]
PHOTO_QUALITY	[none]
COMMENTS	[none]

7.3.4 Data Source

NASA ARC Aircraft Data and Sensor Facilities Zeiss aerial mapping cameras are the source of the photography. The source of the parameter values contained in the inventory listing file on the CD-ROM are:

Column Name	Data Source
SPATIAL_COVERAGE	[Assigned by BORIS staff from spatial information]
DATE_OBS	[Extracted from flight summary report]
START_TIME	[Extracted from flight summary report]
END_TIME	[Extracted from flight summary report]
C130_START_LATITUDE	[Extracted from flight summary report]
C130_START_LONGITUDE	[Extracted from flight summary report]
C130_END_LATITUDE	[Extracted from flight summary report]
C130_END_LONGITUDE	[Extracted from flight summary report]
C130_MISSION_ID	[Extracted from flight summary report]
C130_LINE_NUM	[Extracted from flight summary report]
C130_RUN_NUM	[Extracted from flight summary report]
C130_SITE	[Extracted from flight summary report]
PLATFORM_TRACKING	[Extracted from flight summary report]
PLATFORM_ALTITUDE	[Extracted from flight summary report]
SENSOR_ID	[Extracted from flight summary report]
FOCAL_LENGTH	[Extracted from flight summary report]

```
FILM_TYPE                       [Extracted from flight summary report]
START_FRAME_NUM                 [Derived from review of film rolls]
END_FRAME_NUM                   [Derived from review of film rolls]
CLOUD_COVER                     [Extracted from flight summary report]
PHOTO_QUALITY                   [Extracted from flight summary report]
COMMENTS                        [Extracted from flight summary report]
```

7.3.5 Data Range

There is no data range information for the aerial photography. 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	16-APR-94	17-SEP-94	None	None	None	None
START_TIME	1422	2217	None	None	None	None
END_TIME	1426	2237	None	None	None	None
C130_START_LATITUDE	53.06167	56.12667	-999	None	None	None
C130_START_LONGITUDE	-106.5117	-97.87167	-999	None	None	None
C130_END_LATITUDE	53.17333	56.05167	-999	None	None	None
C130_END_LONGITUDE	-106.6183	-97.84	-999	None	None	None
C130_MISSION_ID	94-004-09	94-009-09	None	None	None	None
C130_LINE_NUM	1	703	999	None	None	None
C130_RUN_NUM	1	3	99	None	None	None
C130_SITE	429	433	999	None	None	None
PLATFORM_TRACKING	1	359	-999	None	None	None
PLATFORM_ALTITUDE	2148	8025	-999	None	None	None
SENSOR_ID	N/A	N/A	None	None	None	None
FOCAL_LENGTH	153.16	305.11	None	None	None	None
FILM_TYPE	N/A	N/A	None	None	None	None
START_FRAME_NUM	0	493	None	None	None	None
END_FRAME_NUM	0	496	None	None	None	None
CLOUD_COVER	N/A	N/A	None	None	None	Blank
PHOTO_QUALITY	N/A	N/A	None	None	None	None
COMMENTS	N/A	N/A	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 C130 photographs is not applicable. The following are wrapped versions of the first few records from the level-0 C130 photograph inventory table on the CD-ROM:

```
SPATIAL_COVERAGE,DATE_OBS,START_TIME,END_TIME,C130_START_LATITUDE,
C130_START_LONGITUDE,C130_END_LATITUDE,C130_END_LONGITUDE,C130_MISSION_ID,
C130_LINE_NUM,C130_RUN_NUM,C130_SITE,PLATFORM_TRACKING,PLATFORM_ALTITUDE,
SENSOR_ID,FOCAL_LENGTH,FILM_TYPE,START_FRAME_NUM,END_FRAME_NUM,CLOUD_COVER,
PHOTO_QUALITY,COMMENTS
'SSA-9OA',16-APR-94,1606,1610,53.53,-105.965,53.68167,-106.32,'94-004-09',301,1,
'429',306.0,4754.0,'ZEISS-075',153.16,'AEROCHROME IR 2448',1,2,'','GOOD','CLEAR'
'SSA-9OA',16-APR-94,1606,1610,53.53,-105.965,53.68167,-106.32,'94-004-09',301,1,
'429',306.0,4754.0,'ZEISS-085',305.11,'AEROCHROME MS 2443',1,4,'','GOOD','CLEAR'
'SSA-9OA',16-APR-94,1625,1629,53.62833,-105.8867,53.63,-106.3583,'94-004-09',303,
2,'429',278.5,4754.0,'ZEISS-075',153.16,'AEROCHROME IR 2448',3,9,'','GOOD',
'CLEAR'
```

8. Data Organization

8.1 Data Granularity

The smallest orderable unit of data for level-0 C-130 photography is an individual photographic frame.

8.2 Data Format(s)

The 9-inch x 9-inch transparencies from single or multiple flight lines are contained on large film rolls delivered by ARC.

The CD-ROM inventory file containing information about the transparencies 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.

The files containing digitized versions of some of the C-130 photography on the CD-ROM are stored in the Joint Photographic Experts Group (JPEG) file format. The standard file naming convention is date_studyarea_site_res.jpg, where res is an indicator of the relative resolution of the images, with h = high and l = low. A number 2 will sometimes follow this indicator if there are two images for a given site/study area/date/resolution combination. The site given in the file name does not mean that this is the only site covered within the image, multiple auxiliary sites are sometimes within each frame or will be covered by a tower site image, particularly if it is a low-resolution image. If a site is not found among the file names, view an image for a nearby site, as your area of interest may be covered within other images. Most of the C-130 photographs were acquired over tower and auxiliary sites within the modeling sub areas, some auxiliary sites were not covered.

Software to view the JPEG images is available from many Internet sites.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

Standard photographic processing of the original negatives to positive transparencies was performed based on the manufacturer's film developing specifications.

9.2 Data Processing Sequence

9.2.1 Processing Steps

BORIS staff processed the level-0 C-130 aerial photography by:

- Reviewing the film on the rolls with the flight logs obtained from ARC to check for discrepancies in numbers of frames and coverage
- Compiling the information into spreadsheets for loading into the online data base
- Loading the spreadsheet information into data base tables
- Cross-checking the photographic information against data collected by other instrument systems on the C-130 aircraft

BOREAS Information System (BORIS) staff processed the JPEG images by:

- Viewing rolls of film on a light table to identify good frames of site coverage. Extracting the frames of interest from the film rolls, noting the frame number, mission, and film type,
- Scanning the transparencies using a digital scanner,
- Replacing the scanned frames within the film rolls,
- Post-processing the imagery in Adobe Photoshop to a) orient the imagery with the edge closest to north at the top, b) cropping images to the edge of the frame, c) adjusting the images for brightness, contrast, and hue if necessary,
- Saving images in JPEG format with a quality level of 6.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

During flight, shutter speed and F-stops were altered as necessary to ensure correct camera operations at varied altitudes and aircraft speeds. No postflight adjustments were performed on the cameras other than normal maintenance.

9.3.2 Calculated Variables

Not applicable.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

None at this time.

10.2 Quality Assessment

10.2.1 Data Validation by Source

ARC and BORIS personnel reviewed the film for overall quality by viewing the resultant photographic imagery.

10.2.2 Confidence Level/Accuracy Judgment

Confidence is high that the photographs do in fact cover the areas that are indicated in the flight logs and that the film, filter, and lenses shown are the ones that were used.

10.2.3 Measurement Error for Parameters

Interested users can refer to USGS calibration reports available from the Airborne Science Data Facility at ARC.

10.2.4 Additional Quality Assessments

None.

10.2.5 Data Verification by Data Center

BORIS staff processed the level-0 C-130 aerial photography by:

- Reviewing the film on the rolls with the flight logs obtained from ARC to check for discrepancies in numbers of frames and coverage
- Compiling the information into spreadsheets for loading into the online data base
- Loading the spreadsheet information into data base tables
- Cross-checking the photographic information against data collected by other data systems on the C-130 aircraft
- Digitizing and enhancing some of the photographs for storage on the CD-ROM set as JPEG files.

11. Notes

11.1 Limitations of the Data

To date, no discrepancies or problems have been noted in the film or the JPEG files.

11.2 Known Problems with the Data

None.

11.3 Usage Guidance

None.

11.4 Other Relevant Information

None.

12. Application of the Data Set

Although the C-130 photography was not planned for photogrammetric activities, it would be useful for documenting the vegetation and ground conditions during the digital scanner data collection missions.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

While reviewing the film and flight logs, BORIS personnel compiled information in Microsoft Excel spreadsheet files for use in loading the online data base. The spreadsheet files were then loaded into the data base with existing Oracle utilities. The JPEG files were created by scanning the transparencies on a flatbed scanned and using Adobe Photoshop to prepare and view the final files.

14.2 Software Access

Contact Adobe, Microsoft, or Oracle Corporation for details on Photoshop, Excel, or Oracle data base software. Many Internet sites contain software that can be obtained to view JPEG files.

15. Data Access

The level-0 C-130 aerial photography is 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

Not applicable to photographic images.

16.2 Film Products

Natural-color and color-IR aerial photography and video records were collected. The video records include aircraft crew cabin intercom conversations and an audible tone that was initiated each time the digital scanner systems were triggered. The BOREAS data base contains an inventory of available BOREAS aircraft flight documentation, such as flight logs and videos.

16.3 Other Products

Although the inventory is contained on the BOREAS CD-ROM set, the actual level-0 C130 photographs are not. See Section 15 for information about how to obtain the data. Several images taken in 1994 are available as JPEG files on the CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Airborne Instrumentation Research Project - Flight Summary Reports for Flight No. 94-004-09 to 94-009-09 or April 16, 1994, to September 19, 1994. NASA Ames Research Center, Airborne Missions and Applications Division, Moffett Field, California, 94035.

Flight summary reports for all the C-130 BOREAS missions. Available from the Airborne Science Data Facility at Ames Research Center. Flight Summary Reports as follows:

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94-004 Series          16-Apr-1994 -- 20-Apr-1994
94-006 Series          23-May-1994 -- 18 June 1994
94-005-04              12 July 1994
94-007 Series          18 July-1994 -- 8 August 1994
94-009 Series          06-17 September 1994
```

NASA. 1990. C-130 Earth Resources Aircraft Experimenter's Handbook. National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California.

Reference USGS camera calibration reports. Available from the Airborne Science Data Facility at Ames Research Center.

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

```
AGL     - Above Ground Level
ARC     - Ames Research Center
ASAS    - Advanced Solid-State Array Spectroradiometer
ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CD-ROM  - Compact Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
FFC-T   - Focused Field Campaign - Thaw
FFC-W   - Focused Field Campaign - Winter
FOV     - Field-Of-View
GIS     - Geographic Information System
GMT     - Greenwich Mean Time
GSFC    - Goddard Space Flight Center
IFC     - Intensive Field Campaign
IFOV    - Instantaneous Field-of-View
IR      - Infrared
JPEG    - Joint Photographic Experts Group
MSS     - Multispectral Scanner
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
SSA     - Southern Study Area
TIMS    - Thermal Infrared Multispectral Scanner
TM      - Thematic Mapper
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TMS     - Thematic Mapper Simulator
URL     - Uniform Resource Locator
USGS    - U. S. Geological Survey
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13. ABSTRACT *(Maximum 200 words)*
For BOREAS, C-130 and other aerial photography was collected to provide finely detailed and spatially extensive documentation of the condition of the primary study sites. The NASA C-130 Earth Resources aircraft can accommodate two mapping cameras during flight, each of which can be fitted with 6- or 12-inch focal-length lenses and black-and-white, natural-color, or color-IR film, depending upon requirements. Both cameras were often in operation simultaneously, although sometimes only the lower resolution camera was deployed. When both cameras were in operation, the higher resolution camera was often used in a more limited fashion. The acquired photography covers the period of April to September 1994. The aerial photography was delivered as rolls of large format (9 x 9 inch) color transparency prints, with imagery from mulitiple missions (hundreds of prints) often contained within a single roll. A total of 1533 frames were collected from the C-130 platform for BOREAS in 1994. Note that the level-0 C130 transparencies are not contained on the BOREAS CD-ROM set. An inventory file is supplied on the CD-ROM to inform users of all the data that were collected. Some photographic prints were made from the transparencies. In addition, BORIS staff digitized a subset of the tranparencies and stored the images in JPEG format. The CD-ROM set contains a small subset of the collected aerial photography that were the digitally scanned and stored as JPEG files for most tower and auxiliary sites in the NSA and SSA. See Section 15 for information about how to acquire additional imagery.

14. SUBJECT TERMS
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