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

Forrest G. Hall and Jaime Nickeson, Editors

Volume 69

BOREAS RSS-16 Level-3b DC-8 AIRSAR SY Images

S. Saatchi, J.A. Newcomer, R. Strub, F. Irani

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

August 2000
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:

- 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 and Jaime Nickeson, Editors

Volume 69

BOREAS RSS-16 Level-3b DC-8 AIRSAR SY Images

Sasan Saatchi, Jet Propulsion Laboratory, Pasadena, California
Jeffrey A. Newcomer and Richard Strub, Raytheon ITSS
Fred Irani, Hughes STX

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

August 2000
BOREAS RSS-16 Level-3b DC-8 AIRSAR SY Images

Sasan Saatchi, Jeffrey A. Newcomer, Richard Strub, Fred Irani

Summary

The BOREAS RSS-16 team used satellite and aircraft SAR data in conjunction with various ground measurements to determine the moisture regime of the boreal forest. RSS-16 assisted with the acquisition and ordering of NASA JPL AIRSAR data collected from the NASA DC-8 aircraft. The NASA JPL AIRSAR is a side-looking imaging radar system that utilizes the SAR principle to obtain high-resolution images that represent the radar backscatter of the imaged surface at different frequencies and polarizations. The information contained in each pixel of the AIRSAR data represents the radar backscatter for all possible combinations of horizontal and vertical transmit and receive polarizations (i.e., HH, HV, VH, and VV). Geographically, the data cover portions of the BOREAS SSA and NSA. Temporally, the data were acquired from 12-Aug-1993 to 31-Jul-1995. The level-3b AIRSAR SY data are the JPL synoptic product and contain 3 of the 12 total frequency and polarization combinations that are possible. The data are stored in binary image format files.

Please note: None of the AIRSAR imagery is contained on the BOREAS CD-ROM. An inventory listing of data collected is included.

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 RSS-16 Level-3b DC-8 AIRSAR SY Images

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 of the relevant aircraft image data. Data from
the Airborne Synthetic Aperture Radar (AIRSAR) system onboard the National Aeronautics and Space Administration (NASA) DC-8 aircraft were acquired by staff at the Jet Propulsion Laboratory (JPL) and provided for use by BOREAS researchers.

1.3 Objective/Purpose
The purpose of this data set is to provide multifrequency and multipolarization Synthetic Aperture Radar (SAR) images over the BOREAS Southern Study Area (SSA). This data set supplements other visible and near-infrared remote sensing images compiled by BOREAS. The level-3b AIRSAR data were acquired at three frequencies of P-band, L-band, and C-band and for all linear polarization combinations (HH, HV, VH, and VV). The level-3b AIRSAR SY image data products contain data from three frequency and polarization combinations. AIRSAR images are used to estimate surface parameters such as canopy water content, soil moisture, and stand biomass and density.

1.4 Summary of Parameters
SAR parameters: incidence angle, aircraft altitude, range resolution, azimuth resolution, frequency, polarization.

1.5 Discussion
AIRSAR image data gathering for BOREAS was conducted in 1993 and 1994 over the two study areas in Canada. BOREAS was designed to study regional land surface climatology and to develop methods for deriving quantitative information about surface variables from remote sensing data. The AIRSAR experiment was devised to provide surface moisture and vegetation variables suitable for the soil-vegetation-atmosphere interaction models. In particular, the high-resolution data obtained by the AIRSAR system can be used to derive information about the variability of the surface parameters, which in turn can be used to address the scaling problem.

1.6 Related Data Sets
BOREAS RSS-16 Level-3b DC-8 AIRSAR CM Images

2. Investigator(s)

2.1 Investigator(s) Name and Title
Dr. Sasan S. Saatchi

2.2 Title of Investigation
Estimation of Evapotranspiration Using SAR Derived Parameters

2.3 Contact Information
Contact 1:
Dr. Sasan S. Saatchi
Jet Propulsion Laboratory
Mail Stop 300-243
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-1051
saatchi@bacchus.jpl.nasa.gov
3. Theory of Measurements

The basic quantity measured by a polarimetric radar is a complex (amplitude and phase) scattering matrix for each resolution element of the radar image. This implies that AIRSAR is a multichannel system designed to maintain phase coherence between radar antennas and different channels. The polarization states used in the AIRSAR system are based on horizontal and vertical antennas. The radar is configured to measure all possible combinations available from the horizontal (H) and vertical (V) antennas (i.e., H transmitting, H receiving, and so forth). The complete scattering matrix for a resolution element can then be determined. Knowledge of the scattering matrix permits calculation of the received power for any possible combination.

4. Equipment

4.1 Sensor/Instrument Description

SAR refers to a technique used to synthesize a very long antenna by combining signals (echoes) received by the radar as it moves along its flight track. NASA JPL currently maintains and operates the AIRSAR/Topographic SAR (TOPSAR), which flies on the NASA DC-8 aircraft.

The AIRSAR system is an airborne SAR that operates simultaneously in a fully polarimetric mode at three frequencies (P-, L-, and C-bands). JPL operates the radar aboard the NASA Ames Research Center DC-8 aircraft. The data collected by the AIRSAR system are processed to polarimetric imagery at JPL and provided to the BOREAS Information System (BORIS) in digital and photographic forms. The AIRSAR system provides several output products, including real-time imagery and the final processed digital products. Two of the most common digital products are the Compressed Matrix (CM) products and the Synoptic (SY) products.

The real-time imagery is provided to the investigators for a SAR pass. This is a low-resolution, black-and-white, single-frequency/polarization (typically LHH) image of the entire pass. No digital data of this type are provided. Annotation of the image allows the investigators to select areas for further processing. The information on the data includes run name (name assigned to the data acquisition pass, typically the site name), Greenwich Mean Time (GMT) (day of year followed by GMT), A/C Lat-Lon, frame count, and frequency/polarization.

The standard SY consists of three floating-point digital image files, one for each of the three selected channel and polarization combinations, and a color photograph. The synoptic images are 62 km along-track with a 10-15 km across-track swath. As part of the standard products, the data sets are
calibrated by the ground SAR processor.

During the 1993 experiment, only limited data were collected over the BOREAS study areas. In 1994, a large amount of imagery was collected and is summarized in Section 7. In 1995, a special collection effort was planned to collect imagery over an area of the SSA that had been burned the previous season.

4.1.1 Collection Environment

The AIRSAR system operates within the fuselage of the DC-8 aircraft during flight. The AIRSAR was flown at medium altitudes aboard NASA's DC-8 aircraft based at NASA JPL and provided 11-m slant range resolution at an altitude of 8,000 m.

4.1.2 Source/Platform

NASA DC-8 Aircraft

4.1.3 Source/Platform Mission Objectives

The objective was to acquire multipolarization and multifrequency SAR images over the BOREAS study areas and transect region.

4.1.4 Key Variables

Polarization, radar frequency, radar look angle, aircraft altitude, range resolution, azimuth resolution, site lat-long coordinates, aircraft geometry.

4.1.5 Principles of Operation

All DC-8 AIRSAR SY level-3b images are produced at 6 m in range and 12 m in azimuth resolutions.

The NASA JPL AIRSAR is a side-looking imaging radar system that utilizes the SAR to obtain high-resolution images that represent the radar backscatter of the imaged surface at different frequencies and polarizations.

4.1.6 Sensor/Instrument Measurement Geometry

During the BOREAS experiment, the instrument was located in the NASA DC-8 aircraft approximately 7,800 m above ground. The antennas are located on the port side of the aircraft looking at an angle over the site. The nominal pointing angle was 28 degrees, which covered the ground surface from approximately 28 to 72 degrees.

4.1.7 Manufacturer of Sensor/Instrument

NASA JPL
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4321

4.2 Calibration

4.2.1 Specifications

In one mode of operation, this system is capable of simultaneously collecting all four polarizations (HH, HV, VH, and VV) for three frequencies: L-band (lambda ~ 24 cm), C-band (lambda ~ 6 cm), and P-band (lambda ~ 68 cm). In another mode of operation, the AIRSAR/TOPSAR system collects all four polarizations (HH, HV, VH, and VV) for two frequencies: L-band (lambda ~ 24 cm) and P-band (lambda ~ 68 cm), while operating as an interferometer at C-band to simultaneously generate topographic height data.

AIRSAR/TOPSAR also has an along-track interferometer mode that is used to measure current speeds. Typical image sizes for AIRSAR/TOPSAR products are 12 km x 12 km, with 10-m resolution in both dimensions. Topographic map products generated by the TOPSAR system have been shown to have a height accuracy of 1 m in relatively flat areas and 5 m in mountainous areas.
4.2.1.1 Tolerance
Each image contains detailed calibration information in the header information area.

4.2.2 Frequency of Calibration
Much of the data produced by the AIRSAR are now calibrated, so that the radar backscatter measurements are in normalized radar cross-section format (m²/m²) or $\sigma_0$ (sigma zero). Sigma zero is the radar cross-section (measured in m²) normalized by the area of the measurement, which in this case is the pixel area in square meters.

4.2.3 Other Calibration Information
Two types of complementary calibration techniques are used for AIRSAR data calibration: internal calibration, and external calibration. For the internal calibration, the information collected from the system tests that are performed regularly during the flight is used to obtain calibration parameters to be used in the AIRSAR processor. This will ensure that all the polarization channels are calibrated relative to one another at each frequency. For external calibration, which calibrates the radar cross-section of the scene absolutely and removes channel imbalance and the cross-talk, information from the scene and dihedral corner reflectors as external targets is used. Investigators who are interested in checking the accuracy of the calibration and performing other corrections themselves can request a copy of the POLCAL software and the user’s manual directly from JPL.

5. Data Acquisition Methods
The AIRSAR system acquires data during flights of the DC-8 aircraft. The instrument system acquires the data across the various spatial elements while the aircraft motion provides the forward motion for image acquisition.

6. Observations

6.1 Data Notes
None given.

6.2 Field Notes
None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage
The BOREAS AIRSAR SY level-3b images cover sections of the Northern Study Area (NSA) and the SSA; however, a majority of the imagery was collected over the SSA. The SSA and the NSA are located in the southwest and northeast portions of the overall BOREAS region.

Each image covers a 12-km along-track and 10-km across-track area. The images contain 1,280 pixels in each of the approximately 5,000 lines. There are three dates of SY imagery over the SSA and one date over the NSA.
The North American Datum of 1983 (NAD83) corner coordinates of the SSA are:

<table>
<thead>
<tr>
<th></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></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
Resolution in range: 6.66 m (across-track) Resolution in azimuth: 12.27 m (along-track)

7.1.4 Projection
The Remote Sensing Science (RSS)-16 team informed BORIS personnel that the images have been resampled into a regular spatial grid; however, the details of the projection used are not known.

7.1.5 Grid Description
The RSS-16 team informed BORIS personnel that the images have been resampled into a regular spatial grid; however, the details of the gridding are not known.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
The AIRSAR SY level-3b data were collected on four dates in the period from 12-Aug-1993 to 31-Jul-1995.

<table>
<thead>
<tr>
<th>Date</th>
<th>Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-Aug-1993</td>
<td>SSA</td>
</tr>
<tr>
<td>13-Aug-1993</td>
<td>NSA</td>
</tr>
<tr>
<td>21-Jul-1994</td>
<td>SSA</td>
</tr>
<tr>
<td>31-Jul-1995</td>
<td>SSA</td>
</tr>
</tbody>
</table>

7.2.3 Temporal Resolution
Most of the SSA Modeling Sub-Area (MSA) was covered by the AIRSAR SY images on two or three occasions from 12-Aug-1993 to 31-Jul-1995.

7.3 Data Characteristics
7.3.1 Parameter/Variable
Radar backscatter of the imaged surface. 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>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were collected.</td>
</tr>
<tr>
<td>BANDS_PRESENT</td>
<td>The bands and polarization combinations present in the image.</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>BAND_QUALITY</td>
<td>The data analyst's assessment of the quality of the spectral bands in the data.</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>The data analyst's assessment of the cloud cover that exists in the data.</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>The NAD83 based latitude coordinate of the north-west corner of the image.</td>
</tr>
<tr>
<td>NW_LONGITUDE</td>
<td></td>
</tr>
<tr>
<td>NE_LATITUDE</td>
<td></td>
</tr>
<tr>
<td>NE_LONGITUDE</td>
<td></td>
</tr>
<tr>
<td>SW_LATITUDE</td>
<td></td>
</tr>
<tr>
<td>SW_LONGITUDE</td>
<td></td>
</tr>
<tr>
<td>SE_LATITUDE</td>
<td></td>
</tr>
<tr>
<td>SE_LONGITUDE</td>
<td></td>
</tr>
<tr>
<td>JPL_PRODUCT_ID</td>
<td></td>
</tr>
<tr>
<td>IMAGE_TITLE</td>
<td></td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td></td>
</tr>
</tbody>
</table>

7.3.2 Variable Description/Definition
The information contained in each pixel of the AIRSAR data represents the radar backscatter for all possible combinations of horizontal and vertical transmit and receive polarizations (i.e., HH, HV, VH, and VV). 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>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were collected.</td>
</tr>
<tr>
<td>BANDS_PRESENT</td>
<td>The bands and polarization combinations present in the image.</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>BAND_QUALITY</td>
<td>The data analyst's assessment of the quality of the spectral bands in the data.</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>The data analyst's assessment of the cloud cover that exists in the data.</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>The NAD83 based latitude coordinate of the north-west corner of the image.</td>
</tr>
</tbody>
</table>
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.

**JPL_PRODUCT_ID**  
The JPL Radar Data Center product identifier.

**IMAGE_TITLE**  
The name of the image assigned by the JPL operations person during processing.

**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
The image pixel values are unitless. 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>TIME_OBS</td>
<td>[HHMM GMT]</td>
</tr>
<tr>
<td>BANDS_PRESENT</td>
<td>[none]</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>BAND_QUALITY</td>
<td>[none]</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>[none]</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>
</tbody>
</table>

Page 8
### 7.3.4 Data Source

The imagery was collected by the AIRSAR sensor aboard the NASA DC-8 research aircraft and were processed and provided by the Radar Data Center at JPL, Pasadena, CA. The sources 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>[Derived by BORIS from latitude and longitude information supplied in the image data files]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Extracted from the image data files by BORIS developed software]</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>[Extracted from the image data files by BORIS developed software]</td>
</tr>
<tr>
<td>BANDS_PRESENT</td>
<td>[Extracted from the image data files by BORIS developed software]</td>
</tr>
<tr>
<td>PLATFORM</td>
<td>[Constant value]</td>
</tr>
<tr>
<td>INSTRUMENT</td>
<td>[Constant value]</td>
</tr>
<tr>
<td>NUM_BANDS</td>
<td>[Extracted from the image data files by BORIS developed software]</td>
</tr>
<tr>
<td>PLATFORM_ALTITUDE</td>
<td>[Extracted from the image data files by BORIS developed software]</td>
</tr>
<tr>
<td>BAND Qualität</td>
<td>[Constant software value]</td>
</tr>
<tr>
<td>CLOUD_COVER</td>
<td>[Constant software value]</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
<tr>
<td>NW_LONGITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
<tr>
<td>NE_LATITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
<tr>
<td>NE_LONGITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
<tr>
<td>SW_LATITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
<tr>
<td>SW_LONGITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
<tr>
<td>SE_LATITUDE</td>
<td>[Derived by BORIS developed software from the starting and ending latitude, longitude coordinates and the pointing information included in the image files.]</td>
</tr>
</tbody>
</table>
7.3.5 Data Range

The maximum range of digital numbers in each level-3b AIRSAR image band is limited from 0 (zero) to 65535 so that the values can be 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:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missng Data Value</th>
<th>Unrel Data Value</th>
<th>Below Detect Limit</th>
<th>Not Data Limit</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>
</tr>
<tr>
<td>DATE_OBS</td>
<td>12-AUG-93</td>
<td>31-JUL-95</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>1604</td>
<td>2113</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>BANDS_PRESENT</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>PLATFÖRM</td>
<td>DC-8</td>
<td>DC-8</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>
</tr>
<tr>
<td>NUM_BANDS</td>
<td>3</td>
<td>3</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>PLATFORM_ALTITUDE</td>
<td>7345.4</td>
<td>7868.1</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>
</tr>
<tr>
<td>CLOUD COVERAGE</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NW_LATITUDE</td>
<td>53.92537</td>
<td>56.14205</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NW_LONGITUDE</td>
<td>-106.55999</td>
<td>-98.23569</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NE_LATITUDE</td>
<td>53.91082</td>
<td>56.07435</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NE_LONGITUDE</td>
<td>-106.17733</td>
<td>-97.58292</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SW_LATITUDE</td>
<td>53.52876</td>
<td>55.8636</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SW_LONGITUDE</td>
<td>-106.60211</td>
<td>-98.32464</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SE_LATITUDE</td>
<td>53.51435</td>
<td>55.79483</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SE_LONGITUDE</td>
<td>-106.22306</td>
<td>-97.6762</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>JPL_PRODUCT_ID</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>IMAGE_TITLE</td>
<td>N/A</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>CPI</td>
<td>CPI</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.
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
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 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-3b AIRSAR SY images is not available here. The following is a sample of the first few records from the level 3b AIRSAR SY inventory table on the CD-ROM:

```
SPATIAL_COVERAGE,DATE_OBS,TIME_OBS,BANDS_PRESENT,PLATFORM,INSTRUMENT,NUM_BANDS,
PLATFORM_ALTITUDE,BAND_QUALITY,CLOUD_COVER,NW_LATITUDE,NW_LONGITUDE,NE_LATITUDE,
NE_LONGITUDE,SW_LATITUDE,SW_LONGITUDE,SE_LATITUDE,SE_LONGITUDE,JPL_PRODUCT_ID,
IMAGE_TITLE,CRTFCN_CODE
'SSA',12-AUG-93,1604,'C-VV, L-HH, P-HH','DC-8','AirSAR',3,7504.8,'NOT ASSESSED',
'NOT ASSESSED',53.97062,-106.55999,53.95561,-106.17733,53.57871,-106.60211,
53.56385,-106.22306,'SY3756C','PRINCE ALBERT WEST 360-1 (A)' , 'CPI'
'SSA',12-AUG-93,1619,'C-VV, L-HH, P-HH','DC-8', 'AirSAR',3,7485.0,'NOT ASSESSED',
'NOT ASSESSED',53.96017,-106.24633,53.94603,-105.90726,53.56353,-106.29197,
53.54952,-105.95613,'SY3753C','PRINCE ALBERT WEST 180-1 (A)' , 'CPI'
```

8. Data Organization

8.1 Data Granularity

The smallest unit of level-3b AIRSAR SY imagery tracked by BORIS is a single three-band scene.

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-3b AIRSAR SY image from BORIS is contained in three files. Each record of a level-3b AIRSAR SY data file contains 5,120 bytes. The first three records in each file contain header information. The number of data records in a file varies depending on the length of the flight line. Each data record of 5,120 bytes contains 1,280 pixels, each stored in a 32-bit (4-byte) binary VAX floating point value. More specific information is as follows:

FILE 1 (5,120-byte records)
- JPL AIRSAR New Header Record (Record 1)
  - 20 records, each containing 50 American Standard Code for Information Interchange (ASCII) characters.
  - 4,120 fill bytes.
- JPL AIRSAR Old Header Record (Record 2)
  - 64 records, each containing 50 ASCII characters.
  - 1,920 fill bytes.
9. Data Manipulations

9.1 Formulae
None.

9.1.1 Derivation Techniques and Algorithms
None given.

9.2 Data Processing Sequence

9.2.1 Processing Steps
BORIS staff makes the AIRSAR SY level-3b images available by:
- Duplicating the JPL-delivered images for backup purposes.
- Extracting pertinent header information from the images for use in inventorying the level-3b image by date and time in the online database.
- Reviewing the content of the extracted header information for potential problems/anomalies.
- Loading the needed information into the online database.

9.2.2 Processing Changes
None.
9.3 Calculations

9.3.1 Special Corrections/Adjustments
None given.

9.3.2 Calculated Variables
None given.

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
None given.

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 reviews the images using developed software that was designed based on data product format documents received from JPL personnel. The software reads through the data products on tape and summarizes the contents in ASCII files on disk. These files are reviewed visually by BORIS personnel for anomalous items.

11. Notes

11.1 Limitations of the Data
None given.

11.2 Known Problems with the Data
None given.

11.3 Usage Guidance
None given.

11.4 Other Relevant Information
None given.
12. Application of the Data Set

AIRSAR images are used to estimate surface parameters such as canopy water content, soil moisture, and stand biomass and density.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

BORIS staff developed software and command procedures to:

- Check and extract information from level-3b AIRSAR SY images on tape and write the information to ASCII files on disk.
- Read the ASCII disk file and log the level-3b AIRSAR SY images into the Oracle data base tables.

The software mentioned under items 1 and 2 is written in the C language 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.

14.2 Software Access

All of the described software is available upon request. BORIS staff would appreciate knowing of any problems discovered with the software, but cannot promise to fix them.

15. Data Access

The level-3b DC-8 AIRSAR SY 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 AIRSAR level-3b SY data can be made available on 8-mm or Digital Archive Tape (DAT) media.

16.2 Film Products

During the data acquisition flight, 35-mm photographs were taken of the areas imaged by the AIRSAR system. Anyone interested in these photographs should contact Dr. Sasan Saatchi (see Section 2.3).

16.3 Other Products

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

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation


NASA JPL. Date unknown. AIRSAR Data Formats, Chapter 4.

NASA JPL. 1995. AIRSAR Integrated Processor Documentation: DATA FORMATS. Version 0.01.

17.2 Journal Articles and Study Reports


van Zyl, J. 1992. The AIRSAR System. JPL.

van Zyl, J. 1995. AIRSAR Integrated Processor Documentation, version 0.01, April 21, 1995.

17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms
None.

19. List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRSAR</td>
<td>Airborne Synthetic Aperture Radar</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>BOREAS</td>
<td>BOREal Ecosystem-Atmosphere Study</td>
</tr>
<tr>
<td>BORIS</td>
<td>BOREAS Information System</td>
</tr>
<tr>
<td>BPI</td>
<td>Bytes Per Inch</td>
</tr>
<tr>
<td>CCT</td>
<td>Computer Compatible Tape</td>
</tr>
<tr>
<td>CD-ROM</td>
<td>Compact Disk-Read-Only Memory</td>
</tr>
<tr>
<td>CM</td>
<td>Compressed Matrix</td>
</tr>
<tr>
<td>DAAC</td>
<td>Distributed Active Archive Center</td>
</tr>
<tr>
<td>DAT</td>
<td>Digital Archive Tape</td>
</tr>
<tr>
<td>EOS</td>
<td>Earth Observing System</td>
</tr>
<tr>
<td>EOSDIS</td>
<td>EOS Data and Information System</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GMT</td>
<td>Greenwich Mean Time</td>
</tr>
<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center</td>
</tr>
<tr>
<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
</tr>
<tr>
<td>MSA</td>
<td>Modeling Sub-Area</td>
</tr>
<tr>
<td>NAD83</td>
<td>North American Datum of 1983</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NSA</td>
<td>Northern Study Area</td>
</tr>
<tr>
<td>ORNL</td>
<td>Oak Ridge National Laboratory</td>
</tr>
<tr>
<td>PANP</td>
<td>Prince Albert National Park</td>
</tr>
<tr>
<td>RSS</td>
<td>Remote Sensing Science</td>
</tr>
<tr>
<td>SAR</td>
<td>Synthetic Aperture Radar</td>
</tr>
<tr>
<td>SSA</td>
<td>Southern Study Area</td>
</tr>
<tr>
<td>SY</td>
<td>Synoptic</td>
</tr>
<tr>
<td>TORSAR</td>
<td>Topographic SAR</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
</tbody>
</table>
20. Document Information

20.1 Document Revision Date
Written: 31-Jul-1995
Last Updated: 11-Jun-1999

20.2 Document Review Date(s)
BORIS Review: 05-Jun-1998
Science Review:

20.3 Document ID

20.4 Citation
When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

The AIRSAR data were provided by the Radar Data Center at NASA's Jet Propulsion Laboratory.

If using data from the BOREAS CD-ROM series, also reference the data as:


Also, cite the BOREAS CD-ROM set as:


20.5 Document Curator

20.6 Document URL
The BOREAS RSS-16 team used satellite and aircraft SAR data in conjunction with various ground measurements to determine the moisture regime of the boreal forest. RSS-16 assisted with the acquisition and ordering of NASA JPL AIRSAR data collected from the NASA DC-8 aircraft. The NASA JPL AIRSAR is a side-looking imaging radar system that utilizes the SAR principle to obtain high-resolution images that represent the radar backscatter of the imaged surface at different frequencies and polarizations. The information contained in each pixel of the AIRSAR data represents the radar backscatter for all possible combinations of horizontal and vertical transmit and receive polarizations (i.e., HH, HV, VH, and VV). Geographically, the data cover portions of the BOREAS SSA and NSA. Temporally, the data were acquired from 12-Aug-1993 to 31-Jul-1995. The level-3b AIRSAR SY data are the JPL synoptic product and contain 3 of the 12 total frequency and polarization combinations that are possible. The data are stored in binary image format files.