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

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

Available from:

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

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

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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 (m^2/m^2) or σ_0 (sigma zero). Sigma zero is the radar cross-section (measured in m^2) 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:
                        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
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.

7.2.2 Temporal Coverage Map

```
   Date                 Study Area
   ----------           ----------
   12-Aug-1993             SSA
   13-Aug-1993             NSA
   21-Jul-1994             SSA
   31-Jul-1995             SSA
```

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:

```
            Column Name
-------------------------------
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
```

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:

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.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
BANDS_PRESENT	The bands and polarization combinations present in the image.
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.
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.
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 north east corner of the minimum bounding rectangle for the data.
NE_LONGITUDE	The NAD83 based longitude coordinate of the north east corner of the minimum bounding rectangle for the data.
SW_LATITUDE	The NAD83 based latitude coordinate of the south west 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 south east 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:

Column Name	Units
SPATIAL_COVERAGE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
BANDS_PRESENT	[none]
PLATFORM	[none]
INSTRUMENT	[none]
NUM_BANDS	[counts]
PLATFORM_ALTITUDE	[meters]
BAND_QUALITY	[none]
CLOUD_COVER	[none]
NW_LATITUDE	[degrees]
NW_LONGITUDE	[degrees]
NE_LATITUDE	[degrees]
NE_LONGITUDE	[degrees]
SW_LATITUDE	[degrees]
SW_LONGITUDE	[degrees]
SE_LATITUDE	[degrees]

```
SE_LONGITUDE                        [degrees]
JPL_PRODUCT_ID                      [none]
IMAGE_TITLE                         [none]
CRTFCN_CODE                         [none]
```

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:

```
        Column Name                         Data Source
-------------------------------  -----------------------------------------------
SPATIAL_COVERAGE                 [Derived by BORIS from latitude and longitude
                                  information supplied in the image data files]
DATE_OBS                         [Extracted from the image data files by BORIS
                                  developed software]
TIME_OBS                         [Extracted from the image data files by BORIS
                                  developed software]
BANDS_PRESENT                    [Extracted from the image data files by BORIS
                                  developed software]
PLATFORM                         [Constant value]
INSTRUMENT                       [Constant value]
NUM_BANDS                        [Extracted from the image data files by BORIS
                                  developed software]
PLATFORM_ALTITUDE                [Extracted from the image data files by BORIS
                                  developed software]
BAND_QUALITY                     [Constant software value]
CLOUD_COVER                      [Constant software value]
NW_LATITUDE                      [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
NW_LONGITUDE                     [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
NE_LATITUDE                      [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
NE_LONGITUDE                     [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
SW_LATITUDE                      [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
SW_LONGITUDE                     [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
SE_LATITUDE                      [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
```

```
                                  coordinates and the pointing information
                                  included in the image files.]
     SE_LONGITUDE                 [Derived by BORIS developed software from the
                                  starting and ending latitude, longitude
                                  coordinates and the pointing information
                                  included in the image files.]
     JPL_PRODUCT_ID               [Extracted from the image data files by BORIS
                                  developed software]
     IMAGE_TITLE                  [Extracted from the image data files by BORIS
                                  developed software]
     CRTFCN_CODE                  [Assigned by BORIS]
```

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:

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	12-AUG-93	31-JUL-95	None	None	None	None
TIME_OBS	1604	2113	None	None	None	None
BANDS_PRESENT	N/A	N/A	None	None	None	None
PLATFORM	DC-8	DC-8	None	None	None	None
INSTRUMENT	N/A	N/A	None	None	None	None
NUM_BANDS	3	3	None	None	None	None
PLATFORM_ALTITUDE	7345.4	7868.1	None	None	None	None
BAND_QUALITY	N/A	N/A	None	None	None	None
CLOUD_COVER	N/A	N/A	None	None	None	None
NW_LATITUDE	53.92537	56.14205	None	None	None	None
NW_LONGITUDE	-106.55999	-98.23569	None	None	None	None
NE_LATITUDE	53.91082	56.07435	None	None	None	None
NE_LONGITUDE	-106.17733	-97.58292	None	None	None	None
SW_LATITUDE	53.52876	55.8636	None	None	None	None
SW_LONGITUDE	-106.60211	-98.32464	None	None	None	None
SE_LATITUDE	53.51435	55.79483	None	None	None	None
SE_LONGITUDE	-106.22306	-97.6762	None	None	None	None
JPL_PRODUCT_ID	N/A	N/A	None	None	None	None
IMAGE_TITLE	N/A	N/A	None	None	None	None
CRTFCN_CODE	CPI	CPI	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-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.

- JPL AIRSAR Parameter Header Record (Record 3)
  - 87 records, each containing 50 ASCII characters.
  - 770 fill bytes.
- JPL AIRSAR SY image data records (Record 4 to end of file)
  - (1,280 pixels stored as 32-bit VAX floating point values)

FILE 2 (5,120-byte records)
- JPL AIRSAR New Header Record (Record 1)
  - 20 records, each containing 50 ASCII characters.
  - 4,120 fill bytes.
- JPL AIRSAR Old Header Record (Record 2)
  - 64 records, each containing 50 ASCII characters.
  - 1,920 fill bytes.
- JPL AIRSAR Parameter Header Record (Record 3)
  - 87 records, each containing 50 ASCII characters.
  - 770 fill bytes.
- JPL AIRSAR SY image data records (Record 4 to end of file)
  - (1,280 pixels stored as 32-bit VAX floating point values)

FILE 3 (5,120-byte records)
- JPL AIRSAR New Header Record (Record 1)
  - 20 records, each containing 50 ASCII characters.
  - 4,120 fill bytes.
- JPL AIRSAR Old Header Record (Record 2)
  - 64 records, each containing 50 ASCII characters.
  - 1,920 fill bytes.
- JPL AIRSAR Parameter Header Record (Record 3)
  - 87 records, each containing 50 ASCII characters.
  - 770 fill bytes.
- JPL AIRSAR SY image data records (Record 4 to end of file)
  - (1,280 pixels stored as 32-bit VAX floating point values)

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 data base.
- Reviewing the content of the extracted header information for potential problems/anomalies.
- Loading the needed information into the online data base.

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
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 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

Freeman, A. 1998. Synthetic Aperture Radar What is SAR? Synthetic Aperture Radar. (http://www.faqs.org/faqs/sci/Satellite-Imagery-FAQ/part2/section-3.html)

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

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.

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

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AIRSAR   - Airborne Synthetic Aperture Radar
ASCII    - American Standard Code for Information Interchange
BOREAS   - BOReal Ecosystem-Atmosphere Study
BORIS    - BOREAS Information System
BPI      - Bytes Per Inch
CCT      - Computer Compatible Tape
CD-ROM   - Compact Disk-Read-Only Memory
CM       - Compressed Matrix
DAAC     - Distributed Active Archive Center
DAT      - Digital Archive Tape
EOS      - Earth Observing System
EOSDIS   - EOS Data and Information System
GIS      - Geographic Information System
GMT      - Greenwich Mean Time
GSFC     - Goddard Space Flight Center
JPL      - Jet Propulsion Laboratory
MSA      - Modeling Sub-Area
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
RSS      - Remote Sensing Science
SAR      - Synthetic Aperture Radar
SSA      - Southern Study Area
SY       - Synoptic
TORSAR   - Topographic SAR
URL      - Uniform Resource Locator
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13. ABSTRACT *(Maximum 200 words)*

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.

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