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BOREAS RSS-20 POLDER Helicopter-Mounted Measurements of Surface BRDF

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BOREAS RSS-20 POLDER Helicopter-Mounted Measurements of Surface BRDF

Marc Leroy

Summary

This BOREAS RSS-20 data set contains measurements of surface BRDF made by the POLDER instrument over several sites (pine, spruce, fen) of the BOREAS study areas during 1994. Single-point BRDF values were acquired from NASA's WFF helicopter. A related data set collected from the C-130 platform is available, as is POLDER imagery acquired from the C-130. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS RSS-20 POLDER Helicopter-Mounted Measurements of Surface BRDF

1.2 Data Set Introduction

The POLarization and Directionality of Earth Reflectances (POLDER) instrument measures Bidirectional Reflectance Distribution Function (BRDF) and Bidirectional Polarization Distribution Function (BPDF) of terrestrial surfaces in several visible and near-infrared spectral bands. The instrument scanned several surface types (pine, spruce, fen, and others) in the BOReal Ecosystem-Atmosphere Study (BOREAS) study areas during the Intensive Field Campaigns (IFCs) in 1994. Single-point BRDF measurements were acquired either from the C-130 aircraft or the helicopter. POLDER images acquired from the C-130 are also available for illustration purposes.

1.3 Objective/Purpose

The objective of the investigation was to characterize the bidirectional reflectance properties of different cover types in boreal forests over several seasons (IFC-1, -2, and -3). This characterization can then be used to retrieve biophysical parameters such as Leaf Area Index (LAI), chlorophyll content, and structural canopy parameters, either through the use of semi-empirical relations between reflectances and biophysical parameters, or through the inversion of a BRDF radiative transfer model. The overall goal is to establish methodologies for monitoring the ecological state of the boreal forest using remote sensing techniques.

1.4 Summary of Parameters

Surface bidirectional reflectances derived from low-altitude helicopter-borne POLDER measurements over sites of opportunity (no atmospheric correction).

1.5 Discussion

The POLDER instrument measures surface reflectance as a function of wavelength and observation geometry. This data set comprises individual site measurements of surface BRDF made by the POLDER instrument over several surface types (pine, spruce, fen) in the BOREAS Northern Study Area (NSA) and Southern Study Area (SSA), acquired during the 1994 IFCs.

1.6 Related Data Sets

BOREAS RSS-01 PARABOLA SSA Surface Reflectance and Transmittance Data
BOREAS RSS-02 Level-1b ASAS Imagery: At-sensor Radiance in BSQ Format
BOREAS RSS-03 Reflectance Measured from a Helicopter-Mounted Barnes MMR
BOREAS RSS-11 Ground Network of Sun Photometer Measurements
BOREAS RSS-20 POLDER C-130 Measurements of Surface BRDF

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Marc Leroy
Dr. François-Marie Brèon
Patrice Bicheron
Olivier Hautecoeur

2.2 Title of Investigation

Estimation of Photosynthetic Capacity using POLDER Polarization

2.3 Contact Information

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3. Theory of Measurements

POLDER is an optical sensor designed to observe the surface reflectance in visible and near-infrared bands. The main characteristic of the POLDER instrument is that it can observe an area from multiple directions. POLDER has a wide field-of-view (FOV) lens with ± 51° along-track and ± 43° cross-track viewing, and a charge-coupled device (CCD) array detector to collect images.

Two principles of operation should be distinguished during the BOREAS experiment. When POLDER was mounted on the helicopter, the purpose was to collect data over the target at a low altitude, typically 300 m. One image acquired directly over a homogeneous surface provides the BRDF of the experimental site. From the National Aeronautics and Space Administration's (NASA) Ames Research Center (ARC) C-130 aircraft, at high altitude, typically 5500 m, the surface cannot be considered homogeneous. POLDER's capacity to observe an area from various view angles allows for measurement of the complete BRDF with the successive images acquired along different flight axes over the experimental site.

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment

It is mandatory to operate POLDER in totally clear sky conditions, so that the distribution of irradiance does not change from one measurement to another, and so that calculation of reflectances in absolute units from radiances is possible.

4.1.2 Source/Platform

During IFC-1 and IFC-2, the POLDER instrument was installed alternatively on the NASA C-130 aircraft or the NASA Wallops Flight Facility (WFF) helicopter. During IFC-3, the instrument was deployed only on the helicopter. The data described in this document was collected from the WFF helicopter platform.

4.1.3 Source/Platform Mission Objectives

The POLDER mission objective was to collect multiangle and multispectral bidirectional reflectance data over flux tower and auxiliary sites to study the boreal forest canopy.

4.1.4 Key Variables

POLDER measures multispectral radiance in the visible and near infrared domain as a function of solar and view geometry.

4.1.5 Principles of Operation

The POLDER optical system consists of a telecentric lens, a filter wheel, and a CCD array as a detector. The light is almost vertically incident on the filter wheel after passing the telecentric lens. The CCD array (288 x 384 elements) can collect 2-D images. The filter wheel contains 10 slots for spectral filters and polarizers. The first channel is reserved for dark current measurement while the others allow measurements in five spectral bands (443, 550, 670, 864, and 910 nm). Two spectral bands (443 and 864 nm) are associated with three polarized filters oriented by steps of 60°. A 10-channel image, corresponding to the 10 positions of the filter wheel, is collected within 3 seconds, and this acquisition is repeated every 10 seconds.

The POLDER optical system was installed on a horizontal stabilized platform developed by J.E. Kalshoven at NASA Goddard Space Flight Center (GSFC). A vertical gyroscope is integral to the platform and provides the feedback for control. The system kept the POLDER optical axis aligned with respect to true nadir, regardless of the helicopter attitude. On the other hand, the heading and yaw were the same as that of the helicopter. The typical flight altitude was 300 m. During a flight, the helicopter flew from site to site and stabilized itself for a few minutes over each target. These were mostly the BOREAS tower sites and auxiliary sites, but also some targets of opportunity that looked homogeneous within the instrument FOV.

4.1.6 Sensor/Instrument Measurement Geometry

The long axis of the CCD array was set parallel to the aircraft longitudinal axis. An inclinometer was used to record the initial bias between the optical axis and true nadir.

4.1.7 Manufacturer of Sensor/Instrument

The instrument was designed and manufactured by:
Laboratoire d'Optique Atmosphèrique (LOA)
59655 Villeneuve d'Ascq Cedex
Lille, France

4.2 Calibration

Radiometric calibration data were acquired at LOA by J.-Y. Balois before and after the BOREAS experiment (11-May-1994, 24-Oct-1994) using a calibrated integration sphere. The whole exit port of the integration sphere is used to derive the equalization coefficients g_{ij}^{ka} (see definition in Section 9.2.1). For absolute calibration, the exit port is reduced by a diaphragm to illuminate only a small circular area in the center of the CCD array. Readings of 15 x 15 pixel window are corrected for dark current and averaged to obtain the absolute calibration coefficients A^{ka}(see Section 9.2.1).

Other calibration experiments were made during the BOREAS experiment using a 30-inch (0.76-m) diameter portable hemisphere that is owned and operated by NASA's Goddard Space Flight Center (GSFC). This portable hemisphere was made available to Remote Sensing Science (RSS)-20 by Brian Markham and John Schaffer. The calibration of POLDER was performed at the Prince Albert airport when POLDER was installed in C-130 aircraft on 27-May-1994 and 21-Jul-1994.

There is a good agreement between the LOA calibration and the first in situ calibration. The second in situ calibration shows discrepancies greater than 10% for all channels. The reasons for such discrepancies are currently unknown.

4.2.1 Specifications

The general specifications of calibration accuracy were 5% absolute accuracy, 3% interband relative calibration accuracy, and 2% multitemporal relative calibration accuracy.

4.2.1.1 Tolerance

A general rise of the sensitivity was noted between the two calibration experiments made at LOA (11-May-1994, 24-Oct-1994): 8% in the blue (443 nm), 3.5% in the green (550 nm) and in the red (670 nm), 5.5% for the 864 nm channel, and 5% for the 910-nm channel. For subsequent processing, mean coefficients obtained at LOA are used.

4.2.2 Frequency of Calibration

The instrument is generally calibrated once before an experimental campaign and once after the campaign. Calibration was performed at LOA on 11-May-1994 and 24-Oct-1994. Onsite calibration was performed on 27-May-1994 and 21-Jul-1994.

4.2.3 Other Calibration Information

Knowing the spectral radiance at the outport of the sphere or the hemisphere, the sensitivity of the various filters, and the spectral value of the solar exoatmospheric irradiance, the normalized radiance is computed using:

$$L_{norm} = \pi \frac{\sum_{i=1}^{n} L(\lambda_i) S(\lambda_i) \delta\lambda_i}{\sum_{i=1}^{n} E(\lambda_i) S(\lambda_i) \delta\lambda_i}$$

where: L : spectral radiance (W/m^2/sr/µm) as a function of wavelength (λ_i)
S : spectral sensitivity as a function of wavelength
E : spectral exoatmospheric solar irradiance (W/m^2/µm) as a function of wavelength

The normalized radiance is used (see Section 9.2.1) to derive the absolute calibration coefficient A^{ka}.

5. Data Acquisition Methods

During a helicopter flight, the POLDER instrument operated continuously. In data analysis, sites were first selected that were homogeneous within the POLDER FOV. This selection was obtained by looking at the symmetry of the measurement with respect to the principal plane. Each pixel in the image corresponds to a different viewing geometry for a surface that is assumed to be invariant. Thus, the image simultaneously gives a representation of the complete directional signature. The measurements corresponding to the principal plane and the perpendicular plane have been extracted from the image data.

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 following are North American Datum of 1983 (NAD83) coordinates of locations that were visited:

Site	BORIS Grid ID	West Longitude	North Latitude	UTM Easting	UTM Northing	UTM Zone
NSA Old Black Spruce (OBS)	T3R8T	98.48139	55.88007	532462.9	6192628.0	14
NSA Young Jack Pine (YJP)	T8S9T	98.28706	55.89575	544583.9	6194706.9	14
NSA Fen	F0L9T	98.42072	55.91481	536207.9	6196749.6	14
Jack Pine	G7K8P	104.63784	53.90349	523823.6	5972622.0	13
Spruce #1		------	no coordinates given		----------	
Spruce #2	G2L7S	104.63784	53.90349	523823.6	5972622.0	13
Spruce #3		------	no coordinates given		----------	
Aspen		------	no coordinates given		----------	
Bare Soil		------	no coordinates given		----------	
Oat		------	no coordinates given		----------	
Grated Field		------	no coordinates given		----------	
Pasture		------	no coordinates given		----------	
Harvested Field		------	no coordinates given		----------	
Wheat		------	no coordinates given		----------	

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The pixel size is about 2 m when POLDER collects data from the helicopter at a 300-m altitude.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

POLDER data were collected on one of two platforms during the three 1994 IFCs. Dates are indicated in Section 7.2.2. Most experiments took place in the morning, except 16-Sep, G7K8P.

7.2.2 Temporal Coverage Map

Site	BOREAS Ops Grid	IFC-1	IFC-2	IFC-3
Black Spruce	T3R8T	06/07		
Young Jack Pine	T8S9T	06/07		
Spruce 1		06/07		
Aspen				09/06
Bare Soil				09/12
Oat				09/12

Grated Field		09/12
Spruce 2	G2L7S	09/16
Spruce 3		09/16
Fen	F0L9T	09/16
Jack Pine	G7K8P	09/16
Pasture		09/17
Harvested Field		09/17
Wheat		09/17

7.2.3 Temporal Resolution

See Section 7.2.1.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
VIEW_ZEN_ANG
SOLAR_ZEN_ANG
RELATIVE_VIEW_AZ_ANG
REFL_443_NM
REFL_443_NM_POLARIZED
REFL_550_NM
REFL_670_NM
REFL_865_NM
REFL_865_NM_POLARIZED
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
VIEW_ZEN_ANG	The angle from the surface normal (straight up)

	to the observing instrument during the data collection.
SOLAR_ZEN_ANG	The angle from the surface normal (straight up) to the sun during the data collection.
RELATIVE_VIEW_AZ_ANG	The azimuthal angle at which the radiant energy was traveling when measured by the sensor, relative to the solar azimuth. The relative view azimuth angle increases in a clockwise direction from the solar position.
REFL_443_NM	POLDER reflectance at 443 nm taken from the helicopter platform.
REFL_443_NM_POLARIZED	POLDER polarized reflectance at 443 nm taken from the helicopter platform.
REFL_550_NM	POLDER reflectance at 550 nm taken from the helicopter platform.
REFL_670_NM	POLDER reflectance at 670 nm taken from the helicopter platform.
REFL_865_NM	POLDER reflectance at 865 nm taken from the helicopter platform.
REFL_865_NM_POLARIZED	POLDER polarized reflectance at 865 nm taken from the helicopter platform.
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).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
VIEW_ZEN_ANG	[degrees]
SOLAR_ZEN_ANG	[degrees]
RELATIVE_VIEW_AZ_ANG	[degrees]
REFL_443_NM	[percent]
REFL_443_NM_POLARIZED	[percent]
REFL_550_NM	[percent]
REFL_670_NM	[percent]
REFL_865_NM	[percent]
REFL_865_NM_POLARIZED	[percent]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[RSS-20 team]
VIEW_ZEN_ANG	[Calculated using geometry]
SOLAR_ZEN_ANG	[Calculated using position and time]
RELATIVE_VIEW_AZ_ANG	[Calculated using geometry]
REFL_443_NM	[POLDER instrument]
REFL_443_NM_POLARIZED	[POLDER instrument]
REFL_550_NM	[POLDER instrument]
REFL_670_NM	[POLDER instrument]
REFL_865_NM	[POLDER instrument]
REFL_865_NM_POLARIZED	[POLDER instrument]
CRTFCN_CODE	[Assigned by BORIS Staff]
REVISION_DATE	[Assigned by BORIS Staff]

7.3.5 Data Range

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-ASP-HSITE	SSA-SP3-HSITE	None	None	None	None
SUB_SITE	RSS20-BRF01	RSS20-BRF01	None	None	None	None
DATE_OBS	07-JUN-94	17-SEP-94	None	None	None	None
VIEW_ZEN_ANG	0	57	None	None	None	None
SOLAR_ZEN_ANG	30.6	57.4	None	None	None	None
RELATIVE_VIEW_AZ_ANG	0	270	None	None	None	None
REFL_443_NM	.81	16.68	None	None	None	None
REFL_443_NM_POLARIZED	-1.86	6.33	None	None	None	None
REFL_550_NM	1.93	25.5	None	None	None	None
REFL_670_NM	.97	34.61	None	None	None	None
REFL_865_NM	8.12	63.77	None	None	None	None
REFL_865_NM_POLARIZED	-8.82	17.39	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	22-JAN-99	22-JAN-99	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

The following is a sample of the first few records from the data table on the CD-ROM:

```
SITE_NAME,SUB_SITE,DATE_OBS,VIEW_ZEN_ANG,SOLAR_ZEN_ANG,RELATIVE_VIEW_AZ_ANG,
REFL_443_NM,REFL_443_NM_POLARIZED,REFL_550_NM,REFL_670_NM,REFL_865_NM,
REFL_865_NM_POLARIZED,CRTFCN_CODE,REVISION_DATE
'SSA-FEN-FLXTR','RSS20-BRF01',16-SEP-94,0.0,55.3,0.0,1.53,.25,3.22,3.8,15.17,
-.06,'CPI',22-JAN-99
'SSA-FEN-FLXTR','RSS20-BRF01',16-SEP-94,2.0,55.3,0.0,1.63,.34,3.15,3.79,14.38,
-.09,'CPI',22-JAN-99
'SSA-FEN-FLXTR','RSS20-BRF01',16-SEP-94,4.0,55.3,0.0,1.75,.27,3.6,4.43,15.05,.3,
'CPI',22-JAN-99
'SSA-FEN-FLXTR','RSS20-BRF01',16-SEP-94,6.0,55.3,0.0,1.75,.28,3.75,4.52,15.34,
.04,'CPI',22-JAN-99
```

8. Data Organization

8.1 Data Granularity

The smallest amount of data that can be ordered from this data set is a day's worth of data for a given site.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) 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.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

See Section 9.2.

9.1.1 Derivation Techniques and Algorithms

See Section 9.2.

9.2 Data Processing Sequence

9.2.1 Processing Steps

9.2.1.1 Level 1 Images

The raw radiometric data are digital numbers noted CN_{ij}^{ka}, where i, j are indices of pixel location on the CCD matrix, k is the wavelength, and a is the polarizer number for spectral bands comprising three polarizers. For the other spectral bands, a is meaningless. The processing from level 0 to level 1 data consists of the transformation of raw data into data proportional to normalized radiances S_{ij}^{ka}, according to the equation:

$$S_{ij}^{ka} = \frac{t_0 \left(CN_{ij}^{ka} - \overline{CN_j^0}\right)}{t \, A^{ka} \, g_{ij}^{ka} \, e^{-\beta^k (T - T_0)}}$$

where: t_0 -- reference exposure time, used in calibration : 100 ms
t -- exposure time during operation
CN_j^0 -- average of line j of dark current
A^{ka} -- calibration coefficient
g_{ij}^{ka} -- relative sensitivity (high and low frequency) of instrumental (optics + CCD) transmission. It is normalized such that the local average of g_{ij}^{ka} at the matrix center equals 1.
β^k -- sensitivity of absolute calibration to CCD temperature
T_0 -- CCD temperature during calibration
T -- CCD temperature in operation
S_{ij}^{ka} -- is a digital number proportional to the observed normalized radiance (for the channels without polarizers)

$$S_{ij}^{ka} = 10000 \frac{\pi L_{ij}^k}{E^k}$$

where: L_{ij}^k -- observed radiance ($W/m^2/sr/\mu m$) for pixel i, j in band k
E^k -- exoatmospheric solar irradiance in band k ($W/m^2/\mu m$)

For polarized bands, the aircraft displacement between successive channel acquisition must be taken into account to obtain a normalized spectral radiance from the three polarized channels

$$\frac{1}{3}\sum_{x=1}^{3} S_{xy}^{kx} = 10000\frac{\pi L_{xy}^{k}}{E^{k}}$$

where (x,y) are surface coordinates that refer to CCD pixels coordinates (i,j) in each of the polarized channels viewing the same ground point (x,y). The level 1 images provide data that for each band are equal to the right-hand side of the two previous equations. They are essentially normalized radiances.

9.2.1.2 BRDF Over Tower Sites

Radiance to Reflectance:

The radiance is converted to reflectance $R_{ij}{}^{k}$ according to

$$R_{ij}^{k} = \frac{\pi L_{ij}^{k}}{E^{k}\cos\theta_{s}}$$

$Ø_s$ where is the solar zenith angle.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.3.2 Calculated Variables

Radiance and reflectance were calculated.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

For images and BRDF data, there is some uncertainty in the absolute calibration coefficient, as illustrated by the calibration tables shown above. For the BRDF data, an additional source of error results from image registration. In the processing, it is assumed that the position of the site is the same for all images of the sequence, which can induce a error in the location of less than 1 pixel. These errors are lessened with the spatial averaging procedure. The smoothing aspect of the BRDF data tends to show that the misregistration errors are not critical.

10.2 Quality Assessment

10.2.1 Data Validation by Source

The POLDER data have been tested against the four-scale BRDF reflectance model (Leblanc et al., 1997) as well as against the PARABOLA data and the DART 3-D BRDF model (Gastellu-Etchegorry et al., 1997).

10.2.2 Confidence Level/Accuracy Judgment

The uncertainty associated with POLDER spectral reflectances values, taking into account only error in the absolute calibration coefficient, is approximately less than 0.005 for the visible channels and 0.01 for the near-infrared channel. The confidence level in these measurements is good because of their reproducibility for different axes during the same flight.

10.2.3 Measurement Error for Parameters

Not available.

10.2.4 Additional Quality Assessments

The directional reflectances obtained with POLDER data corrected from atmospheric effects for the flux tower or auxiliary sites can be compared to similar data made by other instruments.

10.2.5 Data Verification by Data Center

BORIS Staff has viewed the data and performed some basic checks before loading.

11. Notes

11.1 Limitations of the Data

None.

11.2 Known Problems with the Data

None.

11.3 Usage Guidance

Non applicable.

11.4 Other Relevant Information

None.

12. Application of the Data Set

The data set could be used for BRDF model inversion and verification of BRDF direct models.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

None given.

14.2 Software Access

Raw data and processing software are available upon request. Contacts are in Section 2.3.

15. Data Access

The POLDER helicopter-mounted measurements of surface BRDF 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

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

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17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

6S	- Second Simulation of the Satellite signal in the Solar Spectrum
ARC	- Ames Research Center
ASCII	- American Standard Code for Information Interchange
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
BPDF	- Bidirectional Polarization Distribution Function
BRDF	- Bidirectional Reflectance Distribution Function
CCD	- Change Coupled Device
DAAC	- Distributed Active Archive Center
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
FOV	- Field of View
GIS	- Geographic Information System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
IFC	- Intensive Field Campaign
LAI	- Leaf Area Index
LOA	- Laboratoire d'Optique Atmospherique
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OA	- Old Aspen
OBS	- Old Black Spruce
OJP	- Old Jack Pine
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
POLDER	- POLarization and Directionality of Earth's Reflectances
RSS	- Remote Sensing Science
SSA	- Southern Study Area
URL	- Uniform Resource Locator
UTM	- Universal Transverse Mercator
WFF	- Wallops Flight Facility
YJP	- Young Jack Pine

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This BOREAS RSS-20 data set contains measurements of surface BRDF made by the POLDER instrument over several sites (pine, spruce, fen) of the BOREAS study areas during 1994. Single-point BRDF values were acquired from NASA's WFF helicopter. A related data set collected from the C-130 platform is available, as is POLDER imagery acquired from the C-130. The data are stored in tabular ASCII files.

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