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BOREAS RSS-14 Level-1 GOES-7 Visible, IR and Water Vapor Images

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Summary

The BOREAS RSS-14 team collected and processed GOES-7 and -8 images of the BOREAS region as part of its effort to characterize the incoming, reflected, and emitted radiation at regional scales. The level-1 BOREAS GOES-7 image data were collected by RSS-14 personnel at FSU and delivered to BORIS. The data cover the period of 01-Jan-1994 through 08-Jul-1995, with partial to complete coverage on the majority of the days. The data include three bands with eight-bit pixel values. No major problems with the data have been identified.

   Note: due to the large size of the images, the level-1 GOES-7 data are not contained on the BOREAS CD-ROM set. An inventory listing file is supplied on the CD-ROM to inform users of what data were collected. The level-1 GOES-7 image data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). See sections 15 and 16 for more information.

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period of 01-Jan-1994 through 08-Jul-1995, with partial to complete coverage on the majority of the days. The data include three bands with eight-bit pixel values. No major problems with the data have been identified.

1.3 Objective/Purpose
For the BOREAS, the level-1 Geostationary Operational Environmental Satellite (GOES)-7 imagery, along with the other remotely sensed images, was collected in order to provide spatially extensive information over the primary study areas at varying spatial scales. The primary objective for the GOES-7 images in 1994 was to collect visible, infrared (IR), and water vapor channel data covering the BOREAS region at a sufficiently high temporal frequency for subsequent use in analyzing weather events and deriving temporal surface radiation parameters and patterns that existed during the Focused and Intensive Field Campaigns (FFCs and IFCs). The transition and shifting of satellites from GOES-7 to GOES-8 in 1995 enabled good quality images to be acquired over the BOREAS region four times per day from January to June 1995, giving a reasonable monitoring data set.

1.4 Summary of Parameters
The level-1 GOES-7 image data for 1994 and 1995 are digital counts for all bands. In addition to the image data, each data file has a header record that contains descriptive information (see Section 8.2).

1.5 Discussion
None given.

1.6 Related Data Sets
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BOREAS RSS-14 Level-1a GOES-8 Images from 1995 and 1996

2. Investigator(s)

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2.2 Title of Investigation
GOES Imagery for the BOREAS Experimental Areas

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3. Theory of Measurements

The GOES mission is to provide the nearly continuous, repetitive observations that are needed to predict, detect, and track severe weather. GOES spacecraft are equipped to observe and measure cloud cover, surface conditions, snow and ice cover, surface temperatures, and the vertical distributions of atmospheric temperature and humidity. They are also instrumented to measure solar X-rays and other energetics, collect and relay environmental data from platforms, and broadcast instrument data and environmental information products to ground stations. The GOES system includes the satellite (with the GOES instrumentation and direct downlink data transmission capability); the National Environmental Satellite, Data and Information Service (NESDIS) facility at Wallops Island, VA; and the ground systems at NESDIS.

4. Equipment

4.1 Sensor/Instrument Description
The original GOES instrument was the Visible and Infrared Spin Scan Radiometer (VISSR), which was an outgrowth of the spin scan radiometer flown aboard several of the Applications Technology Satellite (ATS) series of the National Aeronautics and Space Administration (NASA) research satellites. The VISSR was first flown aboard Synchronous Meteorological Satellite (SMS)-1 and SMS-2 used by the National Oceanic and Atmospheric Administration (NOAA). GOES-1, -2, and -3 were operational satellites that flew the original VISSR instrument. GOES-4 through -7 were flown with a modified instrument package called the VISSR Atmospheric Sounder (VAS). A set of IR sensors was added to provide an atmospheric sounder capability.

The VAS instrument system is an expansion of the VISSR system with improved structural design and some additional capabilities. It consists of the same type of scanning system, a telescope with lighter weight optics made from beryllium instead of conventional materials (glass, steel), eight visible detectors (25 x 24 microradian (μrad) Instantaneous Field of View (IFOV)) and six IR detectors.

The images are centered at 55.0 degrees N and 102.0 degrees W. The visible band data cover the wavelength region of 0.5 to 0.7 micrometers (μm). The IR data are from GOES-7 channel 8 (11.17 (μm)) and the water vapor data are from channel 10 (6.725 (μm)).

```
GOES-7 Channel      Wavelength, µm
    1 (visible)         0.5-0.7
    8 (IR)              11.17
   10 (water vapor)     6.725
```

4.1.1 Collection Environment

GOES-7 orbited Earth in a geostationary orbit at an altitude of 42,000 km. The data were acquired using the FSU Direct Readout Ground System located in Tallahassee, FL, starting 01-Jan-1994 and continuing through 08-Jul-1995.

4.1.2 Source/Platform

Launch and data-available dates for GOES-7 are:

```
Satellite     Launch Date              Data Range
GOES-7        26-Feb-1987       25-Mar-1987 to mid-1995
```

4.1.3 Source/Platform Mission Objectives

See Sections 1.3 and 3.

4.1.4 Key Variables

Reflected radiation Emitted radiation Water vapor

4.1.5 Principles of Operation

The VISSR instrument consists of a scanning system, telescope, IR, and visible sensors. The scanning system consists of a mirror that is stepped mechanically to provide north-to-south viewing, while the 100-rpm rotation of GOES provides west-to-east scanning. The mirror is stepped following each west-to-east scan. The mirror position is controlled by one of two optical encode wheels attached to the axis. Each step of the mirror causes a change of 192 µrad in the scan angle, representing a distance of 6.9 km near nadir. A sequence of 1,821 scans over 18.21 minutes is performed to provide a "full disk" view from just beyond the northern Earth horizon to just beyond the southern Earth horizon.

The scanning mirror reflects the received radiation into a 16-inch diameter telescope. A fiber-optics bundle is used to couple the telescope to eight VIS detectors (sensitive to the 0.54- to 0.70-µm band). The fiber-optics bundle is configured such that each of the eight VIS sensors has a 20 (W-E) x 25 (N-S) µrad Field of View (FOV) on GOES-7. The sensors are arranged in a linear array oriented "North - South" (i.e., perpendicular to the scan direction), thus sweeping out eight parallel scan line paths as the satellite rotates. The FOV provides a ground resolution of 0.9 km (normally referred to as 1 km or 0.5 nautical mile). The system thus provides eight parallel 1-VIS data lines per west-to-east scan, covering the 6.9-km (normally referred to as 8 km or 4 miles) band scanned by each step of the scanning mirror. In addition, germanium relay lenses are used to pass received radiation to two mercury-cadmium-tellurium (HgCdTe) IR detectors by way of a 10.5- to 12.6-µm bandpass filter. The FOV of the IR detectors is 192 µrad (equal to the north-south scan step angle); thus, the IR sensors provide equivalent coverage to the eight visible sensors.

The output from the eight VIS detectors and from one of the two IR detectors (or an average of both IR detectors) is digitized onboard the satellite and transmitted to Earth in real time. The visible data are sampled every 2 microseconds, which yields visible samples spaced at increments of satellite rotation of 20.9 µrad (assuming a nominal satellite spin rate of 100 rpm), or a near-nadir spacing of 3.0 km. Since the IR detector FOV is 192 µrad, the IR data are therefore oversampled in the scan direction. The quantization of the IR data is 8 bits, and of the VIS 6 bits. The visible scanners are digitized with a square root digitizer for better signal-to-noise ratio. The oversampling of the IR data leads to the designation of the IR data as "4 x 2" IR data (4-mile resolution north-south, 2-mile resolution west-east). The full-resolution scan of all sensors in the mode produces about 226 MB of data per image.

4.1.6 Sensor/Instrument Measurement Geometry

When the VISSR/VAS is installed in the spacecraft, its optical axis becomes parallel to the spacecraft spin axis, which must be parallel to Earth's spin axis. The VAS optical axis is thus perpendicular to the direction of the Earth scene. The optically flat scan mirror of the VAS, placed at a 45-degree angle to the VAS optical axis, directs the Earth scene into the VAS. The spinning is accomplished by stepping the scan mirror from 40 degrees, representing the north polar extreme, to 50 degrees, representing the south polar extreme. An angle position encoder integral with the mirror stepping mechanism converts the position information to electrical signals, which are sent to CDA station to aid in reassembly of the Earth scene. The 10 degrees of mirror motion (resulting in 20 degrees of optical angle due to doubling the optical angle at the mirror) is divided into 1,821 steps, each representing 192 μrad optically.

At the image plane, a relatively large FOV is available. Each detector element is dimensional to define the FOV that its signal is intended to represent. For example, the smallest IR field is 192 μrad, defined by a square detector 0.00315 inches on each side. (At synchronous altitude, 192 μrad is equivalent to 5 miles along Earth's surface at the satellite's suborbital point.)

Two focal planes are used in the VAS. Visible spectrum signals are obtained at the principal focus. An optical fiber for each of the eight FOVs defines the field to be measured (25 x 24 μrad) and conveys the impinging light within that FOV to a photomultiplier tube, which converts the light intensity to a proportional electrical current. IR radiation must be sensed by solid-state detectors that are cooled to a low temperature to reduce their intrinsic electrical noise to a level below the electrical equivalent of the least intense radiation to be measured. This cooling is provided by a radiation cooler that radiates excess heat into space. Because of spacecraft design constraints, the cooler must be located away from the prime focal plane. The relay optics provide an appropriate location for an IR focusing mechanism and filter assembly out of the visible light path. The filter assembly contains an 11.2-cm disc, called a filter wheel, that houses 12 spectral-pass band filters. During each scan, one filter is placed in the IR path to acquire data in the desired spectral band. Any one of the filters can be positioned in the IR optical FOV within 350 milliseconds (i.e., during the time that the VAS telescope is not viewing Earth during a given spin). Filters are inserted in the IR path only and are used in the Multispectral Imaging (MSI) and sounding modes. While 38 channels are possible with the filter wheel detector combinations, only 13 bands can be transmitted.

The scanning schedule and the various modes of operation are uploaded to an electronics module in the satellite. The satellite includes an onboard controller that can itself be reprogrammed via the spacecraft command link.

4.1.7 Manufacturer of Sensor/Instrument

Hughes Santa Barbara Remote Sensing (SBRS) Goleta, CA

4.2 Calibration

The VISSR channels are calibrated in a vacuum environment at five instrument temperature plateaus. Some adjustments are made to standardize the bit content and start time of the stretched data scans.

Preflight Calibration
- Visible Channels: The visible channel calibration source is a quartz iodine lamp, the output of which is collimated and spectrally shaped using appropriate optical filters to create an output similar to the Sun over the spectral band of the VISSR visible channels. The output level of the calibration source is established by eight neutral density filters that provide a calibration range from 16% to 100% albedo. The absolute calibration accuracy of the VISSR visible channels is estimated to be +/- 10%.
- Thermal Channels: The VISSR thermal channels are calibrated at eight target scene temperatures between 180 and 315 K, using a temperature-controlled blackbody source. The estimated absolute calibration accuracy is +/- 1.5 degrees C, or +/- 1 percent of full scale, whichever is larger.

Inflight Calibration
- Visible Channels: The inflight calibration is accomplished by viewing the Sun through the complete visible channel optical train via a "side-looking," reduced-aperture collecting prism. The visible channel gains are adjusted in the ground station processing to equalize the eight scanners. This is done to remove stripping of the images. Other gain adjustments are made occasionally for image clarity. Absolute calibrations with the Sun viewer are not part of the GOES operating procedure. However, some research programs have produced limited calibrations for parts of the GOES data record.
- Thermal Channels: The inflight calibration of the VISSR thermal channel is accomplished by monitoring the temperature of a blackbody. This blackbody is activated by command and introduced into the optical path just ahead of the infrared relay optical system. The space view by VISSR provides an approximately zero signal reference in the thermal bands that is used to establish the zero end of the measurement scale.

The level-1 GOES-7 images have not had any calibration applied. Information on calibration procedures can be found at http://haboob.giss.nasa.gov/isccp.html.

4.2.1 Specifications

```
IFOV
     Visible          25 x 24 µrad
     IR               192 x 192 µrad
RESOLUTION (subsatellite)
     Visible          0.9 km
     IR               6.9 km
ALTITUDE             35,600 km
GOES SPIN RATE       100 rpm
SCAN RATE            1,821 scans/min
SCAN RANGE           approx. 60N to 60S degrees latitude
SAMPLES/SCAN         3,822 IR and 15,288 visible samples per PMT
                     detector per Earth scan
```

GOES-7 for 1993 through November 1994 was stationed at approximately 0.0 degrees N, 112.57 degrees W. In November 1994, it was gradually moved westward so that by 23-Feb-1995, it was at approximately 0.0 degrees N, 136.1 degrees W.

4.2.1.1 Tolerance
Not available at this revision.

4.2.2 Frequency of Calibration
Calibration of the visible and IR channels is performed after every scan using internal calibrators that are part of the VAS and VISSR instrumentation. However, routine calibrations are not made on the visible sensor. The calibration procedures for calculating visible radiances and IR brightness temperatures from counts follows Rossow et al. (1992) and Rossow et al. (1995).

4.2.3 Other Calibration Information
It is pertinent to note that the IR values included in the VAS VISSR data stream are recalibrated values from NESDIS operations. No recalibration is performed on the normalized raw visible data. The Synchronous Data Buffer (SDB) uses a lookup table to replace the original IR data values transmitted from the satellite with recalibrated values that are intended to correspond to a predetermined data value versus temperature table. The lookup table is computed by NESDIS weekly, based on calibration parameters received from the instrument.
More information on calibration procedures can be found at http://haboob.giss.nasa.gov/isccp.html

5. Data Acquisition Methods

The GOES-7 image data were acquired using the FSU direct readout ground system located in Tallahassee, FL, starting on 01-Jan-1994 and continuing through 08-Jul-1995.

6. Observations

6.1 Data Notes
Not available at this revision.

6.2 Field Notes
Not applicable.

7. Data Description

7.1 Spatial Characteristics
The VISSR scanning system consists of a mirror that is stepped mechanically to provide north-to-south viewing, while the rotation of GOES provides west-to-east scanning. The mirror is stepped following each west-to-east scan. A sequence of 1,821 scans over 18.21 minutes is performed to provide a "full disk" view from just beyond the northern Earth horizon to just beyond the southern Earth horizon.

The BOREAS level-1 GOES-7 images were subset from the full GOES-7 data frames to cover the entire 1,000-km x 1,000-km BOREAS region. This contains the Northern Study Area (NSA), the Southern Study Area (SSA), the transect region between the SSA and NSA, and some surrounding area.

7.1.1 Spatial Coverage
Based on information contained in the reference latitude and longitude files for the visible, IR, and water vapor bands (see Section 8.2), the following values represent the nominal coverage of the various bands:

	Visible Latitude	Visible Longitude
Northwest	64.757°N	107.037°W
Northeast	65.911°N	87.120°W
Southwest	47.646°N	109.210°W
Southeast	47.916°N	98.087°W

	IR Latitude	IR Longitude
Northwest	64.807°N	107.045°W
Northeast	65.957°N	87.156°W
Southwest	47.758°N	109.212°W
Southeast	48.028°N	98.096°W

	Water Vapor Latitude	Water Vapor Longitude
Northwest	64.605°N	107.088°W
Northeast	65.728°N	87.410°W
Southwest	47.758°N	109.212°W
Southeast	48.028°N	98.096°W

The North American Datum of 1983 (NAD83) corner coordinates
of the 1,000- x 1,000-km BOREAS region are:

	Latitude	Longitude
Northwest	59.97907°N	111.00000°W
Northeast	58.84379°N	93.50224°W
Southwest	51.00000°N	111.00000°W
Southeast	50.08913°N	96.96951°W

7.1.2 Spatial Coverage Map
Not available at this time.

7.1.3 Spatial Resolution
The spatial resolution of each pixel is dependent on the off-nadir scan angle of the sensor and increases from nadir to the scanning extremes. The satellite subpoint resolution of the various channels is:

	North/South	East/West
Visible	1 km	1 km
IR	8 km	4 km
Water Vapor	16 km	4 km

The spatial dimensions of each pixel can be calculated from the provided latitude and longitude coordinate information (see Section 8.2).

7.1.4 Projection
The temporal sequence of images for a given day is spatially aligned and stored in the "GOES Perfect Projection." Detailed information about the projection is not currently available.

7.1.5 Grid Description
Not available at this revision.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
From 01-Jan-1994 through 31-Dec-1994, partial to complete data are available for 348 of the possible 365 days.
From 01-Jan-1995 through 08-Jul-1995, partial data are available for 145 of the possible 189 days.

7.2.2 Temporal Coverage Map
Not available at this revision.

7.2.3 Temporal Resolution
During 1994, the visible and IR images were acquired on the hour and 30 minutes after the hour, 24 hours a day. The water vapor channel data are available only at the top of the hour. Within a given

day, some images may be missing. Partial to complete data are available on 348 out of the 365 days in 1994.

The transition and shifting of satellites from GOES-7 to GOES-8 in 1995 enabled good quality images to be acquired over the BOREAS region a maximum of 12 times per day from January to July, giving a reasonable monitoring data set. After 08-Jul-1995, the GOES images were acquired from the GOES-8 satellite (see BOREAS GOES-8 data sets).

7.3 Data Characteristics

7.3.1 Parameter/Variable
The parameter contained in the image data files is: `Digital Number (DN)`

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

```
        Column Name
--------------------------------
SPATIAL_COVERAGE
DATE_OBS
START_TIME
END_TIME
PLATFORM
INSTRUMENT
NUM_BANDS
BAND_QUALITY
CLOUD_COVER
NUM_VIS_IMAGES
NUM_IR_IMAGES
NUM_WV_IMAGES
CRTFCN_CODE
```

7.3.2 Variable Description/Definition
For the image data files:

```
Digital Number (DN) - The quantized DN derived by the GOES-7 scanning system for
                      the respective channel.
```

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

Column Name	Description
SPATIAL_COVERAGE	The general term used to denote the spatial area over which the data were collected.
DATE_OBS	The date on which the data were collected.
START_TIME	The starting Greenwich Mean Time (GMT) for the data collected.
END_TIME	The ending Greenwich Mean Time (GMT) for the data collected.
PLATFORM	The object (e.g., satellite, aircraft, tower, person) that supported the instrument.
INSTRUMENT	The name of the device used to make the measurements.
NUM_BANDS	The number of spectral bands in the data.
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.
NUM_VIS_IMAGES                                The number of visible GOES-7 images
                                              that are contained in the image product.
NUM_IR_IMAGES                                 The  number of GOES-7 infrared images that are
                                              contained in the image product.
NUM_WV_IMAGES                                 The number of GOES-7 water vapor images that are
                                              contained in the image product.
CRTFCN_CODE                                   The BOREAS certification level of the data.
                                              Examples are CPI (Checked by PI), CGR (Certified
                                              by Group), PRE (Preliminary), and CPI-??? (CPI
                                              but questionable).
```

7.3.3 Unit of Measurement

For the image data files: Digital Number (DN) - counts

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

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

SPATIAL_COVERAGE                       [none]
DATE_OBS                               [DD-MON-YY]
START_TIME                             [HHMM GMT]
END_TIME                               [HHMM GMT]
PLATFORM                               [none]
INSTRUMENT                             [none]
NUM_BANDS                              [counts]
BAND_QUALITY                           [none]
CLOUD_COVER                            [none]
NUM_VIS_IMAGES                         [counts]
NUM_IR_IMAGES                          [counts]
NUM_WV_IMAGES                          [counts]
CRTFCN_CODE                            [none]
```

7.3.4 Data Source

The level-1 GOES-7 image bands were collected by the VISSR instrument on the GOES-7 spacecraft. The raw data were received, processed and subset, and sent to BORIS by personnel within the Department of Meteorology at FSU. The sources of the parameter values contained in the inventory listing file on the CD-ROM are:

```
        Column Name                            Data Source
------------------------------------   ------------------------------------------------------

SPATIAL_COVERAGE                       [Constant software parameter value]
DATE_OBS                               [Level-1 GOES-7 header record]
START_TIME                             [Constant software parameter value]
END_TIME                               [Constant software parameter value]
PLATFORM                               [Constant software parameter value]
INSTRUMENT                             [Constant software parameter value]
NUM_BANDS                              [Constant software parameter value]
BAND_QUALITY                           [Constant software parameter value]
CLOUD_COVER                            [Constant software parameter value]
NUM_VIS_IMAGES                         [Count from processing software]
NUM_IR_IMAGES                          [Count from processing software]
NUM_WV_IMAGES                          [Count from processing software]
CRTFCN_CODE                            [Constant data base value]
```

7.3.5 Data Range

The maximum range of DNs in each GOES image band is limited from 0 to 255 so that the values can be stored in a single 8-bit (1-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	04-JAN-94	08-JUL-95	None	None	None	None
START_TIME	0	0	None	None	None	None
END_TIME	2330	2330	None	None	None	None
PLATFORM	GOES-7	GOES-7	None	None	None	None
INSTRUMENT	N/A	N/A	None	None	None	None
NUM_BANDS	3	3	None	None	None	None
BAND_QUALITY	N/A	N/A	None	None	None	None
CLOUD_COVER	N/A	N/A	None	None	None	None
NUM_VIS_IMAGES	0	48	None	None	None	None
NUM_IR_IMAGES	0	48	None	None	None	None
NUM_WV_IMAGES	0	24	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 that 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 a 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-1 GOES-7 images is not available here. The following are wrapped versions of the first few records from the level-1 GOES-7 inventory table on the CD-ROM:

```
SPATIAL_COVERAGE,DATE_OBS,START_TIME,END_TIME,PLATFORM,INSTRUMENT,NUM_BANDS,
BAND_QUALITY,CLOUD_COVER,NUM_VIS_IMAGES,NUM_IR_IMAGES,NUM_WV_IMAGES,CRTFCN_CODE
'REGION',04-JAN-94,0,2330,'GOES-7','VISSR',3,'NOT ASSESSED','NOT ASSESSED',12,
12,6,'CPI'
'REGION',05-JAN-94,0,2330,'GOES-7','VISSR',3,'NOT ASSESSED','NOT ASSESSED',47,
48,24,'CPI'
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data for level-1 GOES images is the set of images that comprise the acquisitions for a given day from 0 to 2400 Greenwich Mean Time (GMT). This includes all of the visible, IR, and water vapor images acquired during that 24-hour period along with the reference latitude and longitude coordinate files for the visible, IR, and water vapor images. Due to reception or transmission problems, the number of images varies between days. Also, since each image acquisition is contained in a separate file, the number of files for a given day will vary. Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-1 GOES-7 images are not. See Section 15 for information about how to obtain the data.

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 tape of level-1 GOES-7 images contains data from multiple days organized with all the data of day 1 followed by all the data from day 2, etc. The data files for a given day are arranged with the visible images first, followed by the IR images, and then the water vapor images similar to this:

```
Day 1
Visible Channel Time 1
Visible Channel Time 2
Visible Channel Time 3
    .
    .
    .
Visible Channel Time i

Infrared Channel Time 1
Infrared Channel Time 2
Infrared Channel Time 3
    .
    .
    .
Infrared Channel Time j

Water Vapor Channel Time 1
Water Vapor Channel Time 2
Water Vapor Channel Time 3
    .
    .
    .
```

Water Vapor Channel Time k

Day 2
Visible Channel Time 1
    .

    .

Infrared Channel Time 1
    .

    .

Water Vapor Channel Time 1
    .

Water Vapor Channel Time k
    .

    .

    .

Day n

Note that because of missing images caused by reception or transmission problems, image file m in any of the visible, IR, or water vapor sequences does not necessarily correspond to the same time as image file m in any other day. The time fields in the header records must be checked to find the three image channels collected at the same time. The level-1 data were processed to level-1a products that have missing images zero-filled, resulting in images collected at the same time on different days being in the same file position. The data files were generated on a DELL PC system and written to tape with a Silicon Graphics system.

A file of level-1 GOES-7 imagery can contain visible, IR, or water vapor data. The way to distinguish between the file types is by the size of the file and the information contained in the header record at the beginning of each file.

The first record of each image file is a header record. Multiple-byte numeric integer fields are stored as high order byte first. The decimal number fields are Institute of Electrical and Electronics Engineers (IEEE) 4-byte floating point values. Character fields are stored as expected. The format and contents of the header records are:

Bytes	Description
1 - 4	Integer number of pixels per image line. (Binary)
5 - 8	Projection. A "p" indicates a GOES "perfect" projection, which means the satellite movement has been factored out of the image. A raw image has projection "e". American Standard Code for Information Interchange (ASCII)
9 - 12	CreationDate. The image date in YYDDD format, where the DDD is the day of year. A number of 94025 in this field indicates day 25 of 1994. (Binary)
13 - 16	CreationTime. The image GMT time in HHMM format. A number of 905 indicates 9:05 GMT; 2233 is 22:33 GMT. BOREAS images are recorded at the beginning of every half hour. The "on-the-hour" images are usually between 1 and 5 minutes after the hour and the "half-hour" images are usually between 31 and 35 minutes after the hour. (Binary)
17 - 20	Band. Can be "vis", "ir", or "b10" (water vapor). (ASCII)
21 - 24	Not Used. (ASCII)
25 - 28	Decimal latitude of the center of the image in radians. The BOREAS latitude is 0.959931 radians, or 55.0 degrees N. (Binary)
29 - 32	Decimal longitude of the center of the image in radians. The BOREAS

longitude is -1.780236 radians, or -102.0 degrees (102.0 W).
(Binary)

33 - 36   ULLine. The integer starting line number of the full disc image
           from which this subset image was copied. (Binary)

37 - 40   ULElement. The integer starting pixel/element number of the
           full-disc image from which this subset image was copied. This
           together with the ULLine value specifies the "upper-left" point of
           the subset image relative to the satellite full-disc image. The
           coordinate system used here is specific to the Environmental
           Satellite Data, Inc. (ESD) software that archives the images.
           (Binary)

41 - 44   LineRes. The integer ground resolution, in kilometers, of an image
           line. For BOREAS visible bands, it is 1; for BOREAS IR bands,
           it is 8; for BOREAS water vapor bands, it is 16. (Binary)

45 - 48   ElementRes. The integer ground resolution, in kilometers, of an
           image element. For BOREAS visible bands, it is 1; for BOREAS
           IR bands, it is 4; for BOREAS water vapor bands, it is 4.
           (Binary)

49 - 52   Lines. The integer number of lines in the image. For BOREAS visible
           bands, it is 1024; for BOREAS IR bands, it is 128; for
           BOREAS water vapor bands, it is 64. (Binary)

53 - 56   Elements. The number of elements in each line of the image. For
           BOREAS visible bands, it is 1024; for BOREAS IR bands, it is
           256; for BOREAS water vapor bands, it is 256. The total image size
           in bytes is 512 + (Lines * Elements). (Binary)

57 - 60   Prefix [4]. Four-character text prefix. For BOREAS images, it is
           "bor". (ASCII)

61 - 64   Range. The integer number of counts in the images. For BOREAS
           visible bands, it is 64 (i.e., the byte value of the images range
           from 0 to 63). For BOREAS IR and water vapor bands, it is 256
           (0-255). (Binary)

65 - 76   Not Used. (ASCII)

77 - 80   CreationDate2. Integer used only for extra processing of images.
           (Binary)

81 - 84   CreationTime2. Integer used only for extra processing of images.
           (Binary)

85 - 88   ProjLat. Decimal value, not used. Value should be 0. (Binary)

89 - 92   ProjLon. Decimal value, not used. Value should be 0 -1.964717.
           (Binary)

93 - 96   Height. Decimal value for the satellite's "height" in kilometers.
           It should be 42000.0. (Binary)

97 - 512   Not used for the level-1 GOES images, but defined as:
           97 - 112 Junk3 (ASCII)
           113 - 116 DataType (ASCII)
           117 - 120 Junk4 (ASCII)
           121 - 144 Comments (ASCII)
           145 - 160 DateTime (ASCII)
           161 - 216 Junk5 (ASCII)
           217 - 228 Directory (ASCII)
           229 - 296 Junk6 (ASCII)
           297 - 300 Suffix (ASCII)
           301 - 374 Junk7 (ASCII)
           375 - 382 Filename (ASCII)
           383 - 454 Junk8 (ASCII)

```
455 - 462 ColorTable (ASCII)
463 - 510 Junk9 (ASCII)
511 - 512 Junk10 (ASCII)
```

A file of visible channel data on tape consists of 2,049 records of 512 bytes each. The first 512-byte record is a header record. The next 2,048 records comprise the visible image contains unsigned 6-bit counts (i.e., values of 0 to 63) stored in 8-bit (1-byte) values for the 1,024 pixels in each of 1,024 lines. Two successive 512-byte tape records must be concatenated to make each of the 1,024 byte image lines. The pixels of a visible image have a nominal 1-km (north-south) x 1-km (east-west) spatial resolution.

A file of IR channel data on tape consists of 65 records of 512 bytes each. The first 512-byte record is a header record. The next 64 records comprise the IR image, which contains unsigned 8-bit counts (i.e., values of 0 to 255) stored in 8-bit (1-byte) values for the 256 pixels in each of 128 lines. Each 512-byte record contains two 256-pixel image lines. The pixels of an IR image have a nominal 8-km (north-south) x 4-km (east-west) spatial resolution.

A file of water vapor channel data on tape consists of 33 records of 512 bytes each. The first 512-byte record is a header record. The next 32 records comprise the water vapor image, which contains unsigned 8-bit counts (i.e., values of 0 to 255) stored in 8-bit (1-byte) values for the 256 pixels in each of 64 lines. Each 512-byte record contains two 256-pixel image lines. The pixels of a water vapor image have a nominal 16-km (north-south) x 4-km (east-west) spatial resolution.

The six reference latitude and longitude files for all of the GOES-7 images collected in 1994 are on a separate tape from the images because the latitude and longitude files were delivered after the level-1 images were reviewed and processed. The six files consist of a pair of latitude and longitude files for each of the visible, IR, and water vapor image types.

The reference latitude and longitude files for the visible images each consist of 1,024 records of 4,096 bytes. Each record of 4,096 bytes contains 1,024 signed 32-bit (4-byte) integer latitude or longitude values. The bytes of each 32-bit value are stored as low-order byte first. The unit of each latitude and longitude value is thousandths of a degree. To get the original decimal degree values, divide each value by 1,000.

The reference latitude and longitude files for the IR images each consist of 128 records of 1,024 bytes. Each record of 1,024 bytes contains 256 signed 32-bit (4-byte) integer latitude or longitude values. The bytes of each 32-bit value are stored as low-order byte first. The unit of each latitude and longitude value is thousandths of a degree. To get the original decimal degree values, divide each value by 1,000.

The reference latitude and longitude files for the water vapor images each consist of 64 records of 1,024 bytes. Each record of 1,024 bytes contains 256 signed 32-bit (4-byte) integer latitude or longitude values. The bytes of each 32-bit value are stored as low-order byte first. The unit of each latitude and longitude value is thousandths of a degree. To get the original decimal degree values, divide each value by 1,000.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms
None.

9.2 Data Processing Sequence

9.2.1 Processing Steps
FSU created the daily level-1 GOES-7 image sets by:
- Acquiring the data via Direct Readout Ground Station at FSU
- Using ESD software to minimize satellite wobble for image alignment
- Sectorizing the data to cover only the BOREAS region
- Storing the data on optical disk and 8-mm tape
- Writing the images for a given day to Digital Archive Tape (DAT) and 8-mm tape

BORIS staff processed the level-1 GOES-7 images by:
- Copying the DAT tape to an 8-mm version
- Checking the summary information sent by FSU with data processing results
- Inventorying the level-1 images in the online data base

9.2.2 Processing Changes
None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
The scene-to-scene wobble has been minimized by using proprietary ESD remapping software. Details of this processing can be obtained by contacting ESD at:

Environmental Satellite Data, Inc.
5200 Auth Road
Suitland, MD 20746
(301) 423-2113

9.3.2 Calculated Variables
None.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
A potential, but unlikely, source of error is the possible mismatch of image header information with the corresponding image data. Because of the automated nature of this processing, this scenario is very unlikely.

10.2 Quality Assessment

10.2.1 Data Validation by Source
Whatever the processing level, the geometric quality of the image depends on the accuracy of the viewing geometry. Spectral errors could arise because of image-wide signal-to-noise ratio, saturation, cross-talk, spikes, or response normalization caused by change in gain.

10.2.2 Confidence Level/Accuracy Judgment
BORIS checking of the delivered level-1 images with developed software identified some time and other data problems that resulted in some images being deleted from the initial delivery. These images are not included in the current data set. Based on FSU and BORIS quality checks, the data set is considered to be properly inventoried and described. The actual quality of the images in relation to clarity or missing scan lines or dropouts was not assessed.

10.2.3 Measurement Error for Parameters
None.

10.2.4 Additional Quality Assessments
The level-1 GOES-7 images were visually scanned for unusable data by FSU staff.

10.2.5 Data Verification by Data Center
See Section 9.2.1.

11. Notes

11.1 Limitations of the Data
Not available at this revision.

11.2 Known Problems with the Data
Occasional reception problems, especially during NOAA rapid-scan operations, may result in some images being truncated at the northern edge (top of image). When this occurs, visual review by FSU staff has ensured that the BOREAS areas of interest are still present.

11.3 Usage Guidance
None.

11.4 Other Relevant Information
Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-1 GOES-7 images are not. See Section 15 for information about how to acquire actual level-1 GOES-7 images.

12. Application of the Data Set

These data were collected for the purpose of deriving surface radiation fields from the temporal series of images. The data can certainly be used for this purpose or other atmospheric and surface monitoring activities.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description
As noted in Section 9.2, FSU acquires the downlinked raw images on a DELL PC system, transfers them to a Silicon Graphics system, and writes the data to tape. For further information regarding the ESD software used at FSU, please contact:

Environmental Satellite Data, Inc.
5200 Auth Road
Suitland, MD 20746
(301) 423-2113

BORIS staff developed software and command procedures for:
- Extracting header information from the level-1 GOES-7 images on tape and writing it to ASCII files on disk for quality checking
- Inventorying the level-1 images in the online data base by using the extracted header information files
- Creating binary files of scaled latitude and longitude coordinates from the original ASCII files
- Writing the latitude and longitude files to tape

The BORIS software is written in C and is operational on VAX 6410, MicroVAX, and VAXstation systems at GSFC. The primary dependencies in the software are the tape I/O library and the Oracle data base utility routines.

14.2 Software Access

All of the BORIS software is available upon request. BORIS staff would appreciate being informed of any problems discovered with the software, but cannot guarantee that they will be fixed.

15. Data Access

The level-1 GOES-7 visible, IR, and water vapor 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 level-1 GOES data can be made available on 8-mm or DAT tapes.

16.2 Film Products
None.

16.3 Other Products
Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-1 GOES-7 images are not. See Section 15 for information about how to obtain the data.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation
Rossow, W.B., C.L. Brest, M.D. Roiter. 1996. International Satellite Cloud Climatology Project (ISCCP) New Radiance Calibrations. WMO/TD-No. 736. World Meteorological Organization.

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Rossow, W.B., Y. Desormeaux, C.L. Brest, A. Walker. 1992. International Satellite Cloud Climatology Project (ISCCP): Radiance calibration report. WMO/Technical Document No. 520, World Climate Research Programme and World Meteorological Organization (ICSU and WMO), Geneva, Switzerland, 104 pp.

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

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

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

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

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

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

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

17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII	– American Standard Code for Information Interchange
ATS	– Application Technology Satellite
BOREAS	– BOReal Ecosystem-Atmosphere Study
BORIS	– BOREAS Information System
BPI	– Bytes Per Inch
CCT	– Computer Compatible Tape
CD-ROM	– Compact Disk-Read-Only Memory
DAAC	– Distributed Active Archive Center
DAT	– Digital Archive Tape
DN	– Digital Number
FFC	– Focused Field Campaign
FOV	– Field of View
EOS	– Earth Observing System
EOSDIS	– EOS Data and Information System
ESD	– Environmental Satellite Data, Inc.
FFC	– Focused Field Campaign
FOV	– Field-of-View
GIS	– Geographic Information System
GMT	– Greenwich Mean Time
GOES	– Geostationary Operational Environmental Satellite
GSFC	– Goddard Space Flight Center
IEEE	– Institute of Electrical and Electronics Engineers
IFC	– Intensive Field Campaign
IFOV	– Instantaneous Field-of-View
IR	– Infrared
ISLSCP	– International Satellite Land Surface Climatology Project
MB	– Megabyte
MSI	– Multispectral Imaging
NAD83	– North American Datum of 1983
NASA	– National Aeronautics and Space Administration
NSA	– Northern Study Area
NESDIS	– National Environmental Satellite, Data and Information Service
NOAA	– National Oceanic and Atmospheric Administration
ORNL	– Oak Ridge National Laboratory
PANP	– Prince Albert National Park
RSS	– Remote Sensing Science
SBRS	– Santa Barbara Remote Sensing

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SDB      - Synchronous Data Buffer
SMS      - Synchronous Meteorological Satellite
SSA      - Southern Study Area
URL      - Uniform Resource Locator
VAS      - VISSR Atmospheric Sounder
VISSR    - Visible and Infrared Spin Scan Radiometer
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13. ABSTRACT (Maximum 200 words)

The BOREAS RSS-14 team collected and processed GOES-7 and -8 images of the BOREAS region as part of its effort to characterize the incoming, reflected, and emitted radiation at regional scales. The level-1 BOREAS GOES-7 image data were collected by RSS-14 personnel at FSU and delivered to BORIS. The data cover the period of 01-Jan-1994 through 08-Jul-1995, with partial to complete coverage on the majority of the days. The data include three bands with eight-bit pixel values. No major problems with the data have been identified.

Note: due to the large size of the images, the level-1 GOES-7 data are not contained on the BOREAS CD-ROM set. An inventory listing file is supplied on the CD-ROM to inform users of what data were collected. The level-1 GOES-7 image data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). See sections 15 and 16 for more information.

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