BOREAS FOLLOW-ON HMET-01 LEVEL-2 GOES-8 1996 SHORTWAVE AND LONGWAVE RADIATION

Get Data

## Summary

The BOREAS HMet-01 team collected and processed several Level-1 GOES-7 and GOES-8 image data sets for 1994-1996, and GOES-7 Level-2 for 1994 over the BOREAS study region. This data set contains shortwave and longwave radiation images at the surface and top of the atmosphere derived from collected GOES-8 data. These GOES-8 Level-2 data cover the period from 12-Feb-1996 to 22-Oct-1996. There are images missing from the temporal series. The main difference between this data set and 1994 data set is in the spatial coverage and the grid cell size. The data are stored in binary image format files.

Note that some of the data files have been compressed using Zip compression. See Section 8.2 for details.

## Data Citation

Cite this data set as follows (citation revised on October 30, 2002):

Smith, E. A., J. Gu, and J. Nickeson. 2001. BOREAS Follow-On HMet-01 Level-2 GOES-8 1996 Shortwave and Longwave Radiation. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

## Table of Contents



## 1. Data Set Overview

**1.1 Data Set Identification**

BOREAS Follow-On HMet-01 Level-2 GOES-8 1996 Shortwave and Longwave Radiation

### 1.2 Data Set Introduction

For the BOReal Ecosystem-Atmosphere Study (BOREAS) Follow-on, these the level-2 data were processed in order to extend the temporal coverage of the existing spatially extensive data over the primary study areas. These level-2 GOES-8 shortwave and longwave images acquired and processed by Dr. Eric Smith's group at FSU, serve to define the surface radiation budget (SRB) for the BOREAS region.

### 1.3 Objective/Purpose

The primary objectives are 1) to retrieve the SRB from the level-1 GOES-8 visible imagery over the BOREAS region at a high temporal and spatial resolution, and 2) to quantify the uncertainties of satellite-derived SRB products.

### 1.4 Summary of Parameters

The level-2 GOES-8 SW/LW product contains the following parameters:

Scaled Shortwave Down at Surface
Scaled Surface Shortwave Albedo
Scaled PAR down
Scaled PAR Albedo
Scaled Net Longwave at Surface
Scaled Narrow-band Albedo at TOA*
Scaled Shortwave Down at TOA*
Scaled Narrow-band Cloud albedo
Scaled Surface Skin Temperature
Scaled Column Water Vapor Amount
Scaled Narrow_Band Minimum Albedo

* where TOA is the top of the atmosphere, and PAR is photosynthetically active radiation.

### 1.5 Discussion

Dr. Eric Smith, from Florida State University (FSU), team collected and processed several GOES image data sets from 1994 through 1996 to provide high temporal and spatial resolution for BOREAS.

### 1.6 Related Data Sets

BOREAS RSS-14 Level-1 GOES-7 Visible, Infrared, and Water-Vapor Images
BOREAS RSS-14 Level-3 Gridded Radiometer and Satellite Surface Radiation Images
BOREAS RSS-14 Level-1 GOES-8 Visible, Infrared, and Water-Vapor Images
BOREAS RSS-14 Level-1a GOES-8 Visible, Infrared, and Water-Vapor Images

Return to top of document.

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## 2. Investigator(s)

### 2.1 Investigator(s) Name and Title

Dr. Eric A. Smith, Professor

### 2.2 Title of Investigation

Retrieval of Surface Radiation Fluxes Over BOREAS

### 2.3 Contact Information

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Return to top of document.

## 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.

Return to top of document.

## 4. Equipment

### 4.1 Sensor/Instrument Description

The GOES I-M imager on the GOES-8 satellite is a five-channel (one visible, four IR) imaging radiometer for measuring radiant and reflected energy from Earth. Using a servo-driven, two-axis gimbaled mirror scan system with a Cassegrain telescope, the multispectral channels simultaneously sweep an 8-km (5-statute-mile) north-to-south swath along an east-to-west/west-to-east path, at a rate of 20 degrees east-west per second.

The imager consists of electronics, power supply, and sensor modules. The sensor module containing the telescope, scan assembly, and detectors is mounted on a base plate external to the spacecraft, together with the shields and louvers for thermal control. The electronics module provides redundant circuitry and performs command, control, and signal processing functions; it also serves as a structure for mounting and interconnecting the electronic boards for proper heat dissipation. The power supply module contains the converters, fuses, and power control for interfacing with the spacecraft electrical power subsystem. The electronics and power supply modules are mounted on the spacecraft internal equipment panel.

| Imager Instrument Characteristics | Spectral Bands (micrometers) | | | | |
|---|---|---|---|---|---|
| | VIS | IR2 | IR3 | IR4 | IR5 |
| Wavelength (micrometers) | 0.55 to 0.75 | 3.80 to 4.00 | 6.50 to 7.00 | 10.20 to 11.20 | 11.50 to 12.50 |
| Clouds | X | X | X | X | X |
| Water Vapor | | | X | X | X |
| Surface Temp | | 0 | | X | 0 |
| Winds | X | | X | X | |
| Albedo & IR Flux | X | | 0 | X | 0 |
| Fires & Smoke | X | X | | 0 | 0 |

X:  Primary Spectral Channel
0:  Secondary (supplementary) Spectral Channel

| | |
|---|---|
| Field of View Defining Element: | Detector |
| Optical Field of View: | Square |
| 5-channel Imaging: | Simultaneously |
| Scan Capability: | Full Earth/Sector/Area |

| Channel/Detector | Instantaneous Field of View (IFOV) |
|---|---|
| Visible/Silicon | : 1 km |
| Shortwave/InSb | : 4 km |
| Moisture/HgCdTe | : 8 km |
| Longwave 1/HgCdTe | : 4 km |
| Longwave 2/HgCdTe | : 4 km |

Radiometric Calibration:  Space and 290 Kelvin IR internal blackbody

| | |
|---|---|
| Signal Quantizing (NE'delta'T) | : 10 bits all channels |
| S/N | : Minimum 3X better than specifications |
| Frequency of Calibration Space | : 2.2 sec for full disk; |
| | : 9.2 or 36.6 sec for sector/area |
| Infrared | : 30 minutes typical |
| System Absolute Accuracy | : IR channel less than 0.1 K |
| Transmit Frequency | : 1676.00 MHz |

### 4.1.1 Collection Environment

The GOES-8 data were acquired using the FSU Direct Readout Ground System located in Tallahassee, FL, starting on 14-Jul-1995 and continuing through 23-Oct-1996. The GOES-8 satellite orbited Earth in a geostationary orbit at an altitude of 35,788 km (19,324 nautical miles).

### 4.1.2 Source/Platform

Launch and data available dates for the GOES-8 satellite are:

| Satellite | Launch Date | Data Range |
|---|---|---|

```
---------     -----------           -----------------------
GOES-8        13-Apr-1994                0-1024
```

### 4.1.3 Source/Platform Mission Objectives

The mission of the GOES satellite series is to provide the nearly continuous 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.

For BOREAS, the level-1 GOES-8 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 BOREAS was to collect visible, 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 field campaigns. The GOES-8 data set has a significant improvement in spatial resolution over the GOES-7 data from 1994 and early 1995.

### 4.1.4 Key Variables

Reflected radiation
Emitted radiation
Water vapor

### 4.1.5 Principles of Operation

The GOES I-M program is a continuation of the previous National Oceanic and Atmospheric Administration (NOAA)/National Aeronautics and Space Administration (NASA) collaboration to provide continuous monitoring of Earth's environment for weather forecasting and research. The objectives of the GOES I-M program are to maintain and expand the operational, environmental, and storm warning capabilities; to monitor Earth's atmosphere and surface and space environmental conditions; and to introduce improved atmospheric and oceanic observations and data dissemination capabilities.

GOES I-M is a new series of five satellites that meet these objectives, providing significant improvements in weather imagery and atmospheric sounding information in accordance with current weather service requirements, particularly in regard to the forecasting of life- and property-threatening severe storms. A novel space- and ground-based computer and communication system provides users with calibrated and navigated (i.e., Earth-located) imagery and sounding data, in real time.

The GOES I-M spacecraft meet the mission's objectives by providing:

- ♦ Independent imaging and sounding functions with instrument resolution, navigation, channelization, and signal-to-noise characteristics representing improvements over previous GOES missions
- ♦ Full-time weather facsimile transmission
- ♦ Data collection system transponder functions
- ♦ Space environment monitor system
- ♦ Search and rescue transponder functions

The GOES I-M Imaging and Sounding instruments provide significantly improved measurement capability over the previous GOES sensors. The GOES I-M five-channel Imager processes higher spatial resolution (i.e., 4 km for its IR channels) and higher radiometric sensitivity to improve the measurement of cloud and Earth's surface features. Sounding quality is improved by having more spectral channels (18 IR and 1 visible) with greatly improved radiometric sensitivity. The three-axis stabilized platform enables higher quality imagery and sounding data to be achieved through its dwell time advantage over a spinning satellite. The flexibility of scan control by both instruments combined with the three-axis stability enables rapid small-area coverage in addition to hemispheric or full-disk coverage. The new limited-area, higher frequency observation capability permits more continuous monitoring of severe weather development.

The GOES I-M generation of spacecraft has been developed by Space Systems/Loral, Inc. (SS/L). These satellites are three-axis body stabilized, meaning that the three axes of the satellite remain stationary relative to nadir. These satellites use internal momentum wheels to provide attitude control and require corrective action from the ground to compensate for the effects of thermal gradients and solar winds. Unlike the previous GOES D-H series, the GOES I-M spacecraft's Imaging and Sounding instruments can be operated simultaneously and independently of one another.

**4.1.6 Sensor/Instrument Measurement Geometry**

The flexible nature of the Imager is used to provide a star-sensing capability. Time and location of a star are predicted very accurately and related to the spacecraft location and optical field. From a set of these data, the ground control system chooses a location and time that are convenient within the imaging schedule. At the time for the scheduled starlook, the Imager is pointed to the predicted star location, which can be anywhere within its 21 degrees N-S by 23 degrees E-W view. (These viewing limits are for star sensing only. The maximum frame size during normal imaging operations is 19 degrees N-S by 19.2 degrees E-W.) As the star passes through one or two of the eight elements of the visible array, it is sampled for Instrument Navigation & Registration (INR) purposes. The data are in the normal format and data stream for extraction and use at the ground station. During data acquisition for BOREAS, the GOES-8 satellite was stationed at approximately 0.0 degrees N, 75.0 degrees W.

The Imager is a multichannel instrument designed to sense radiant and solar-reflected energy from sampled areas of Earth's surface and atmosphere. The Imager's multi-element spectral channels simultaneously sweep an 8-km north-south (N-S) (longitudinal) swath along an east-west (E-W) (latitudinal) path by means of a two-axis gimbaled mirror scan system. Position and size of an area scan are controlled by command. Beam splitters separate the spectral channels to the various IR detector sets, which are redundant. The 1- by 8-km visible detector array consisting of eight individual detectors is not redundant.

Control of the Imager comes from a defined set of command inputs. The instrument is capable of full Earth imagery, sector imagery that contains the edges of Earth, and various sizes of area scans totally enclosed within the Earth scene. Area scan selection permits rapid, continuous viewing of local areas for monitoring of mesoscale phenomena and accurate wind determination. Area scan size and location are definable to less than one visible pixel to provide complete flexibility.

Motion of the Imager and Sounder scan mirrors causes a small but well-defined disturbance of the spacecraft attitude. This effect is gradually reduced by spacecraft control but at a rate too slow for total compensation. Since all the physical factors of the scanners and spacecraft are known and the scan positions are continuously provided to the Imager and Sounder, the disturbances caused by each scan motion on the spacecraft and distributed to each instrument are calculated by the Attitude and Orbit Control System (AOCS). The Mirror Motion Compensation (MMC) signal is developed and used in the scan system server control loop to slightly modify the scan rate and position to offset the disturbance. This simple signal and control interface provides corrections that reduce any combination of effects. With this system in place, the Imager and Sounder are totally independent, maintaining image location accuracy regardless of the other unit's operational status. If need be, this MMC scheme can be disabled by command.

The AOCS also provides an Image Motion Compensation (IMC) signal that counteracts the spacecraft attitude, orbit effects, and predictable structural-thermal effects within the spacecraft-instrument combination. These effects are detected from ranging, star sensing, and landmark features. Corrective algorithms developed on the ground are fed through the AOCS to the instruments as a total IMC signal, which includes the MMC described above.

The Imager scans the selected image area in alternate directions on alternate lines. The imaging area is defined by a coordinate system related to the instrument's orthogonal scan axis. During imaging operations a scan line is generated by rotating the scanning mirror in the E-W direction while concurrently sampling each of the active imaging detectors. At the end of the line, the Imager scan mirror performs a turnaround, which involves stepping the mirror to the next scan line and reversing the direction of the mirror. The next scan line is then acquired by rotating the scanning mirror in the opposite, west-east direction, again with concurrent detector sampling. Detector sampling occurs within the context of a repeating data block format. In general, all visible detectors are sampled four times for each data block (four times 1 km wide), while each of the active IR detectors is sampled once per data block (one times 4 km wide).

#### 4.1.7 Manufacturer of Sensor/Instrument

Aerospace/Communications Divisions of ITT
McLean, VA

### 4.2 Calibration

The calibration of the IR data and the normalization of the visible data are performed by the Operations Ground Equipment (OGE) on the raw data received from the spacecraft Imaging and Sounding sensors. The calibration/normalization function can be described in terms of those functions that occur during online processing and those that are performed during non-real-time operating modes.

The real-time calibration and normalization of Imager and Sounder data can be divided into a continual application process and a periodic calibration coefficient generating process. In the real-time continual application process, factory-measured detector response characteristics together with in-flight measurements made while viewing space and BB targets are used by the Sensor Processing Subsystem (SPS) to convert raw Imager and Sounder sensor data to theoretical target radiance. All radiometric image data produced by the Imager and Sounder instruments must undergo calibration/normalization processing. This function is performed in the SPS and involves the conversion of instrument output from raw digital counts to its final physical units. For IR data calibration, this process uses the recalculated gain and bias factors to adjust for detector variations over time. This calibration process takes place in the SPS. The visible data normalization is performed so that all detectors of the same instrument produce the same readings when viewing an area of uniform brightness. The data produced by the eight Imager visible channels must be normalized to prevent striping. The normalization process is performed in the SPS with data provided by the Product Monitor (PM). These data are generated by an operator performing a histogram matching using data with the full range of intensities.

The SPS maintains a current calibration data base for each satellite to be used in the real-time calibration of raw Imager and Sounder sensor data. The data base is maintained for both primary and redundant detectors. The SPS maintains the coefficients for the calibration equations that have been supplied to the data base prior to launch. This factory detector response information consists of Imager and Sounder IR nominal coefficients. The SPS data base has the equations for converting the BB thermistor output to temperature and BB temperature to equivalent target radiance. In addition, the data base contains the current calibration coefficients for the IR channels, which are based on the space and BB measurements. These calibration coefficients, computed by the SPS, are the gain and bias factors and coefficients of the quadratic terms. They must be recalculated periodically because it is expected that these factors will vary with the age and temperature of the instruments. This information is maintained, for both the Imager and Sounder, in a data base that resides in the SPS memory.

Normalization for Imager visible data is performed in real time by the Sensor Data Interface (SDI) hardware, through use of look-up tables. For Imager and Sounder IR data, calibration is performed by the SPS software, using the calculated calibration coefficients.

For additional calibration details, see the BOREAS RSS-14 Level-1 GOES-8 Visible, Infrared, and Water-Vapor Images documentation.

#### 4.2.1 Specifications

The level-1 GOES-8 images did not have any calibration applied.

##### 4.2.1.1 Tolerance

None given.

#### 4.2.2 Frequency of Calibration

None given.

#### 4.2.3 Other Calibration Information

None given.

Return to top of document.

## 5. Data Acquisition Methods

The BOREAS level-1 GOES-8 images used in the level-1a product creation were obtained by Dr. Eric Smith at FSU and supplied to BORIS. The data were acquired using the FSU Direct Readout Ground System located in Tallahassee, FL, starting on 14-Jul-1995 and continuing through 23-Oct-1996.

Return to top of document.

## 6. Observations

### 6.1 Data Notes

None.

### 6.2 Field Notes

Not applicable.

Return to top of document.

## 7. Data Description

### 7.1 Spatial Characteristics

The scanning system consists of a mirror that is stepped mechanically to provide north-to-south viewing, while the rotation of the GOES satellite 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-1a GOES-8 images essentially cover the entire 1,000-km by 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

1000x1000 km BOREAS region

The NAD83 corner coordinates of the 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 the gridded data is 4 km E-W and 4 km N-S.

#### 7.1.4 Projection

The area mapped is projected in the BOREAS Grid projection, which is based on the ellipsoidal version of the Albers Equal-Area Conic (AEAC) projection. The projection has the following parameters:

```
Datum:      North American Datum of 1983 (NAD83)
Ellipsoid:  GRS80 or WGS84
Origin: 111.000 degrees West Longitude
         51.000 degrees North Latitude
Standard Parallels:  N 52° 30' 00"
                     N 58° 30' 00"
```

#### 7.1.5 Grid Description

The data are gridded in 4-km intervals based on the projection given in Section 7.1.4. Please note that the data are ordered from south to north, i.e., the first 250 values are for the southern boundary of the domain, while the last 250 values are for the northern boundary of the domain (c.f. the lat/lon file for details).

### 7.2 Temporal Characteristics

#### 7.2.1 Temporal Coverage

12-Feb-1996 to 22-Oct-1996

#### 7.2.2 Temporal Coverage Map

**GOES-8 Level-2 Images**

Shows the number of image files available for each day

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 96-02-12 | 3 | 96-04-17 | 24 | 96-06-14 | 15 | 96-08-25 | 23 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 96-02-13 | 11 | 96-04-18 | 23 | 96-06-15 | 24 | 96-08-26 | 25 |
| 96-02-14 | 14 | 96-04-19 | 24 | 96-06-16 | 1 | 96-08-27 | 20 |
| 96-02-16 | 19 | 96-04-20 | 23 | 96-06-17 | 17 | 96-08-28 | 25 |
| 96-02-17 | 7 | 96-04-21 | 24 | 96-06-18 | 4 | 96-08-29 | 24 |
| 96-02-18 | 7 | 96-04-22 | 24 | | | 96-08-30 | 25 |
| 96-02-19 | 18 | 96-04-23 | 24 | 96-07-04 | 27 | 96-08-31 | 25 |
| 96-02-20 | 12 | 96-04-24 | 18 | 96-07-05 | 26 | | |
| 96-02-23 | 2 | 96-04-25 | 19 | 96-07-06 | 15 | 96-09-01 | 22 |
| 96-02-26 | 17 | 96-04-26 | 23 | 96-07-08 | 18 | 96-09-02 | 6 |
| 96-02-27 | 20 | 96-04-27 | 24 | 96-07-09 | 27 | 96-09-03 | 16 |
| 96-02-28 | 17 | 96-04-28 | 5 | 96-07-10 | 26 | 96-09-04 | 13 |
| 96-02-29 | 19 | 96-04-29 | 22 | 96-07-11 | 20 | 96-09-05 | 10 |
| | | 96-04-30 | 20 | 96-07-12 | 21 | 96-09-06 | 19 |
| 96-03-01 | 19 | | | 96-07-13 | 27 | 96-09-07 | 22 |
| 96-03-02 | 20 | 96-05-01 | 15 | 96-07-14 | 27 | 96-09-08 | 14 |
| 96-03-03 | 15 | 96-05-02 | 4 | 96-07-15 | 24 | 96-09-09 | 20 |
| 96-03-04 | 18 | 96-05-03 | 21 | 96-07-16 | 22 | 96-09-10 | 19 |
| 96-03-05 | 19 | 96-05-04 | 24 | 96-07-17 | 26 | 96-09-11 | 22 |
| 96-03-06 | 17 | 96-05-05 | 2 | 96-07-18 | 4 | 96-09-12 | 20 |
| 96-03-07 | 5 | 96-05-06 | 22 | 96-07-19 | 23 | 96-09-13 | 7 |
| 96-03-11 | 6 | 96-05-07 | 22 | 96-07-20 | 23 | 96-09-16 | 21 |
| 96-03-12 | 19 | 96-05-08 | 24 | 96-07-21 | 26 | 96-09-17 | 21 |
| 96-03-13 | 15 | 96-05-09 | 23 | 96-07-22 | 27 | 96-09-18 | 21 |
| 96-03-14 | 20 | 96-05-10 | 18 | 96-07-23 | 26 | 96-09-19 | 18 |
| 96-03-15 | 21 | 96-05-11 | 2 | 96-07-24 | 26 | 96-09-20 | 22 |
| 96-03-16 | 22 | 96-05-13 | 22 | 96-07-25 | 26 | 96-09-21 | 21 |
| 96-03-17 | 16 | 96-05-14 | 24 | 96-07-26 | 27 | 96-09-22 | 22 |
| 96-03-18 | 16 | 96-05-15 | 23 | 96-07-27 | 5 | 96-09-23 | 21 |
| 96-03-19 | 22 | 96-05-16 | 23 | 96-07-28 | 24 | 96-09-24 | 21 |
| 96-03-20 | 20 | 96-05-17 | 23 | 96-07-29 | 20 | 96-09-25 | 1 |
| 96-03-21 | 22 | 96-05-18 | 12 | 96-07-30 | 25 | 96-09-26 | 10 |
| 96-03-22 | 21 | 96-05-19 | 1 | 96-07-31 | 12 | 96-09-27 | 22 |
| 96-03-23 | 22 | 96-05-20 | 14 | | | 96-09-28 | 21 |
| 96-03-24 | 10 | 96-05-21 | 12 | 96-08-01 | 26 | 96-09-29 | 21 |
| 96-03-25 | 20 | 96-05-22 | 17 | 96-08-02 | 26 | 96-09-30 | 21 |
| 96-03-26 | 19 | 96-05-23 | 7 | 96-08-03 | 26 | | |
| 96-03-27 | 21 | 96-05-24 | 18 | 96-08-04 | 26 | 96-10-02 | 15 |
| 96-03-28 | 22 | 96-05-25 | 20 | 96-08-05 | 25 | 96-10-03 | 9 |
| 96-03-29 | 22 | 96-05-26 | 20 | 96-08-06 | 23 | 96-10-04 | 20 |
| 96-03-30 | 21 | 96-05-27 | 4 | 96-08-07 | 22 | 96-10-05 | 20 |
| 96-03-31 | 22 | 96-05-28 | 17 | 96-08-08 | 26 | 96-10-06 | 19 |
| | | 96-05-29 | 24 | 96-08-09 | 25 | 96-10-07 | 20 |
| 96-04-01 | 23 | 96-05-30 | 8 | 96-08-10 | 25 | 96-10-08 | 20 |
| 96-04-02 | 23 | 96-05-31 | 23 | 96-08-11 | 26 | 96-10-09 | 19 |
| 96-04-03 | 23 | | | 96-08-12 | 24 | 96-10-10 | 20 |
| 96-04-04 | 23 | 96-06-01 | 4 | 96-08-13 | 25 | 96-10-11 | 20 |
| 96-04-05 | 23 | 96-06-03 | 17 | 96-08-14 | 25 | 96-10-12 | 6 |
| 96-04-06 | 23 | 96-06-04 | 17 | 96-08-15 | 25 | 96-10-13 | 21 |
| 96-04-07 | 24 | 96-06-05 | 18 | 96-08-16 | 26 | 96-10-14 | 21 |
| 96-04-08 | 23 | 96-06-06 | 19 | 96-08-17 | 25 | 96-10-15 | 21 |
| 96-04-09 | 23 | 96-06-07 | 9 | 96-08-18 | 25 | 96-10-16 | 21 |
| 96-04-10 | 24 | 96-06-08 | 8 | 96-08-19 | 26 | 96-10-17 | 21 |
| 96-04-11 | 22 | 96-06-09 | 23 | 96-08-20 | 25 | 96-10-18 | 20 |
| 96-04-12 | 15 | 96-06-10 | 25 | 96-08-21 | 25 | 96-10-19 | 21 |
| 96-04-14 | 13 | 96-06-11 | 21 | 96-08-22 | 24 | 96-10-20 | 10 |
| 96-04-15 | 24 | 96-06-12 | 11 | 96-08-23 | 26 | 96-10-21 | 21 |
| 96-04-16 | 22 | 96-06-13 | 1 | 96-08-24 | 26 | 96-10-22 | 21 |

### 7.2.3 Temporal Resolution

The satellite data are collected every 30 minutes (on the hour and half-hour), note, however, that data are not available each day for all 30 minute periods.

## 7.3 Data Characteristics

### 7.3.1 Parameter/Variable

```
1  -  Scaled Shortwave Down at Surface
2  -  Scaled Surface Shortwave Albedo
3  -  Scaled PAR down
4  -  Scaled PAR Albedo
5  -  Scaled Net Longwave at Surface
6  -  Scaled Narrow-band Albedo at TOA
7  -  Scaled Shortwave Down at TOA
8  -  Scaled Narrow-band Cloud albedo
9  -  Scaled Surface Skin Temperature
10 -  Scaled Column Water Vapor Amount
11 -  Scaled Narrow_Band Minimum Albedo
```

### 7.3.2 Variable Description/Definition

```
Variable                                                Wavelength Region
------------------------------------------------        -----------------
1  - Scaled Shortwave Down at Surface                   (0.3 to 3.0 µm)
2  - Scaled Surface Shortwave Albedo                    (0.3 to 3.0 µm)
3  - Scaled PAR down                                    (0.4 to 0.7 µm))
4  - Scaled PAR Albedo                                  (0.4 to 0.7 µm)
5  - Scaled Net Longwave at Surface                     (4.0 to 100.0 µm)
6  - Scaled Narrow-band Albedo at TOA                   (0.5 to 0.7 µm)
7  - Scaled Shortwave Down at TOA                       (0.3 to 3.0 µm)
8  - Scaled Narrow-band Cloud albedo                    (0.5 to 0.7 µm)
9  - Scaled Surface Skin Temperature                    ()
10 - Scaled Column Water Vapor Amount                   ()
11 - Scaled Narrow_Band Minimum Albedo                  (0.5 to 0.7 µm)
```

### 7.3.3 Unit of Measurement

```
Variable                                                      Units
------------------------------------------------        --------------------
1  -  Scaled Shortwave Down at Surface                  (units=0.0500 w/m*m)
2  -  Scaled Surface Shortwave Albedo                   (units=0.0001      )
3  -  Scaled PAR down                                   (units=0.0500 w/m*m)
4  -  Scaled PAR Albedo                                 (units=0.0001      )
5  -  Scaled Net Longwave at Surface                    (units=0.0500 w/m*m)
6  -  Scaled Narrow-band Albedo at TOA                  (units=0.0001      )
7  -  Scaled Shortwave Down at TOA                      (units=0.0500 w/m*m)
8  -  Scaled Narrow-band Cloud albedo                   (units=0.0001      )
9  -  Scaled Surface Skin Temperature                   (units=0.0100 deg c)
10 -  Scaled Column Water Vapor Amount                  (units=0.0100 cm   )
11 -  Scaled Narrow_Band Minimum Albedo                 (units=0.0001      )
```

### 7.3.4 Data Source

The level-2 SW/LW images were derived from the level-1 GOES-8 images by Dr. Eric Smith and his staff at Florida State University.

### 7.3.5 Data Range

Not available.

### 7.4 Sample Data Record

The following is a sample header from one of the image data files:

*Note that the naming of the contents of the images are altered from the rest of this document. This was done to make the names consistent with previous GOES products delivered as part of BOREAS.

```
-----------------------------Begin Sample Header------------------------------

*** BOREAS LEVEL-3 GOES SURFACE RADIATION IMAGE PRODUCT ***
-----------------------------------------------------------

 Record    Contents                                  Scale Factor
 Number
      1  Header Record (This record)       (80 Ascii Characters/Line           )
 02- 11  Scaled Shortwave Down             (16 bit integers, units=0.0500 w/m*m)
 12- 21  Scaled Surface Albedo             (16 bit integers, units=0.0001      )
 22- 31  Scaled PAR Down                   (16 bit integers, units=0.0500 w/m*m)
 32- 41  Scaled PAR Albedo                 (16 bit integers, units=0.0001      )
 42- 51  Scaled L Net                      (16 bit integers, units=0.0500 w/m*m)
 52- 61  Scaled Visible Reflectance at TOA (16 bit integers, units=0.0001      )
 62- 71  Scaled Shortwave Down at TOA      (16 bit integers, units=0.0500 w/m*m)
 72- 81  Scaled Cloud Visible Albedo       (16 bit integers, units=0.0001      )
 82- 91  Scaled Surface Temperature        (16 bit integers, units=0.0100 deg c)
 92-101  Scaled Column Water Vapor         (16 bit integers, units=0.0100 cm   )
102-111  Scaled Minimum Reflectance        (16 bit integers, units=0.0001      )

E-W Resolution          : 4 km
N-S Resolution          : 4 km

Date                    : 10/03/96
Time (UTC)              : 1800
Julian Day              : 277

Image File Specifactions

Bytes     / Grid Cell   :   2
Grid Cells/ Line        : 250
Lines     / Image       : 250

Image                   : 125000 bytes
Image                   : 10     records
Record                  : 12500  bytes
______________________________________________________________

The following radiation parameters can be derived from the above
parameters.

Shortwave Up  = Shortwave Down * Surface Albedo

Shortwave Net = Shortwave Down - Shortwave Up

PAR Up        = PAR Down * PAR Albedo

PAR Net       = PAR Down - PAR Up

Longwave Up   = eps * sigma * (Surface Temperature+273.15)**4
```

```
                (eps = 0.98, sigma = 5.6697e-8)

Longwave Down = L Net + Longwave Up

Net Radiation = Shortwave Net + Longwave Net

All these variables are in W/m**2

-------------------------------End Sample Header------------------------------
```

Return to top of document.

# 8. Data Organization

**8.1 Data Granularity**

Data exist for every half hour when available. The half-hour files have been organized into daily zip files.

**8.2 Data Format**

The data are stored in binary image format files, with an ASCII header record. The image data are stored as 16-bit-integers. The data may need to be byte-swapped to display correctly.

**8.2.1 Uncompressed Format**

The level 2 GOES 8 1996 gridded radiation image data set contains 224 files (see section 7.2.1). The 11-band images (corresponding to the 11 parameters listed sections 1.4 and 7) are stored in band sequential (BSQ) format files (with headers) for each 30 minute time period. To view the image data, a 12,500-byte ASCII header record must be skipped first. The images are 250 samples by 250 lines, each pixel is a two-byte integer, low order byte first. Thus, each file contains 1387500 bytes [12500 header bytes + (250 lines x 250 samples x 2 bytes pixels x 11 bands)].

**8.2.2 Compressed Format**

The image files have been compressed with the MS Windows-standard Zip compression scheme. These files were compressed using Aladdin's DropZip on a Macintosh. DropZip uses the Lempel-Ziv algorithm (Welch, 1994), also used in Zip and PKZIP programs. The compressed files may be uncompressed using PKZIP (with the -expand option) on MS Windows and UNIX, or with StuffIt Expander on the Mac OS. You can get newer versions from the PKZIP Web site at http://www.pkware.com/download-software/ [Internet Link].

Return to top of document.

# 9. Data Manipulations

**9.1 Formulae**

**9.1.1 Derivation Techniques and Algorithms**

The solar parameters were retrieved from Level-1 GOES-8 visible images using a physical retrieval algorithm described in Gu et al. (1999). The algorithm includes parameterization of Rayleigh scattering, water vapor and ozone absorption, aerosol and cloud attenuation, and surface reflection.

The surface net LW flux was obtained from surface downward solar flux and in situ measured near-surface temperature using a statistical algorithm described in Gu et al. (1999).

The basic theory behind this approach is that solar radiation provides the primary energy load modulating the fundamental daily cycle of net LW flux. Variation of surface temperature is the response of the surface to the incident solar energy, which affects the net LW flux through its effect on upward LW flux.

### 9.2 Data Processing Sequence

None given.

#### 9.2.1 Processing Steps

None given.

#### 9.2.2 Processing Changes

None given.

### 9.3 Calculations

None given.

#### 9.3.1 Special Corrections/Adjustments

None given.

#### 9.3.2 Calculated Variables

None given.

### 9.4 Graphs and Plots

None.

Return to top of document.

## 10. Errors

### 10.1 Sources of Error

Potential sources of error include:

- Calibration
- Model parameterization: cloud optical properties, Rayleigh scattering
- Uncertainties in input: column water vapor amount, aerosol optical depth
- Quality of level-1 data

### 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

See Section 11.2.

#### 10.2.4 Additional Quality Assessments

None given.

#### 10.2.5 Data Verification by Data Center

BORIS staff have unpacked and inventoried files available and have.viewed a subset of the imagery to verify image sizes, data type, and format.

Return to top of document.

## 11. Notes

### 11.1 Limitations of the Data

See Section 11.2.

### 11.2 Known Problems with the Data

None given.

### 11.3 Usage Guidance

None given.

### 11.4 Other Relevant Information

None given.

Return to top of document.

## 12. Application of the Data Set

These data were derived for the purpose of using the radiation fields for temporal and spatial modeling at regional scales.

Return to top of document.

## 13. Future Modifications and Plans

Return to top of document.

## 14. Software

### 14.1 Software Description

There are FORTRAN programs available with this data set that can be used to read the header, the image, or the lat-lon files. Sample files are also included.

Lat_lon_dat.zip
read_rad_96.f
sample.output
sample_image.zip

Zip uses the Lempel-Ziv algorithm (Welch, 1994) used in the zip and PKZIP commands.

**14.2 Software Access**

Software are available as part of this data set. Zip is available from many Web sites across the Internet. You can get newer versions from the PKZIP Web site at http://www.pkware.com/download-software/ [Internet Link]. Versions of the decompression software for MS Windows, Mac OS, and several varieties of UNIX systems are included in this archive.

Return to top of document.

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## 15. Data Access

**15.1 Contact for Data Center/Data Access Information**

These BOREAS data are available from the Earth Observing System Data and Information System (EOS-DIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). The BOREAS contact at ORNL is:

ORNL DAAC User Services
Oak Ridge National Laboratory
(865) 241-3952
ornldaac@ornl.gov
ornl@eos.nasa.gov

**15.2 Procedures for Obtaining Data**

BOREAS data may be obtained through the ORNL DAAC World Wide Web site at http://www.daac.ornl.gov/ [Internet Link] or users may place requests for data by telephone or by electronic mail.

**15.3 Output Products and Availability**

Requested data can be provided electronically on the ORNL DAAC's anonymous FTP site or on various media including, CD-ROMs, 8-mm tapes, or diskettes.

Return to top of document.

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## 16. Output Products and Availability

**16.1 Tape Products**

None.

**16.2 Film Products**

None.

**16.3 Other Products**

None.

Return to top of document.

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# 17. References

### 17.1 Platform/Sensor/Instrument/Data Processing Documentation

Bobotek, A., A.S. Hechtman, R.J. Komajoa, and P.G. Woolner. July 1995. GOES I-M System description. MITRE Corporation.

Gu, J., E.A. Smith, and J.D. Merritt, 1999: Testing energy balance closure with GOES-retrieved net radiation and in situ measured eddy correlation fluxes in BOREAS. J. Geophys. Res., 104, 27881-27893.

Kelly, K.A. 1989. GOES I-M image navigation and registration and user Earth location. GOES I-M Operational Satellite Conf., Arlington, VA, US. Department of Commerce, NOAA, 154-167.

Rossow, W.B., C.L. Brest, and M. Roiter. 1996. International Satellite Cloud Climatology Project (ISCCP) New Radiance Calibrations. WMO/TD-No. 736. World Meteorological Organization.

Rossow, W.B., C.L. Brest, and M.D. Roiter. 1995. International Satellite Cloud Climatology Project (ISCCP): Update of radiance calibration report. Technical Document, World Climate Research Programme (ICSU and WMO), Geneva, Switzerland, 76 pp.

Rossow, W.B., Y. Desormeaux, C.L. Brest, and 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

Gu, J. and E.A. Smith. 1997. High-resolution estimates of total solar and PAR surface fluxes over large-scale BOREAS study area from GOES measurements. Journal of Geophysical Research 102(D24):29,685-29,705.

Gu, J., E.A. Smith, G. Hodges, and H.J. Cooper. 1997. Retrieval of Daytime Surface Net Longwave Flux over BOREAS from GOES Estimates of Surface Solar Flux and Surface Temperature. Submitted to Canadian Journal of Remote Sensing.

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. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

Rossow, W.B., C.L. Brest, and M.D. Rotier. 1995. International satellite cloud climatology project (ISCCP): Update of radiance calibration. Technical Document, World Climate Research Program (ICSU and WMO), Geneva, Switzerland, 76 pp.

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.

Return to top of document.

## 18. Glossary of Terms

None given.

Return to top of document.

## 19. List of Acronyms

```
ASCII  - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS  - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory
DAAC   - Distributed Active Archive Center
EOS    - Earth Observing System
EOSDIS - EOS Data and Information System
FFC    - Focused Field Campaign
FOV    - Field of View
FSU    - Florida State University
GMT    - Greenwich Mean Time
GOES   - Geostationary Operational Environmental Satellite
GSFC   - Goddard Space Flight Center
IFC    - Intensive Field Campaign
IFOV   - Instantaneous Field of View
ISCCP  - International Satellite Cloud Climatology Project
NAD83  - North American Datum of 1983
NASA   - National Aeronautics and Space Administration
NESDIS - National Environmental Satellite, Data and Information Service
NOAA   - National Oceanic and Atmospheric Administration
NSA    - Northern Study Area
ORNL   - Oak Ridge National Laboratory
PAR    - Photosynthetically Active Radiation
RSS    - Remote Sensing Science
SRB    - Surface Radiation Budget
SSA    - Southern Study Area
TOA    - Top of the Atmosphere
URL    - Uniform Resource Locator
```

Return to top of document.

## 20. Document Information

### 20.1 Document Revision Dates

Written: 03-Nov-2000
Last Updated: 01-Dec-2000 (citation revised on 30-Oct-2002)

### 20.2 Document Review Dates

BORIS Review: 03-Nov-2000
Science Review:

### 20.3 Document ID

hmet01_g8_l2

### 20.4 Citation

Cite this data set as follows (citation revised on October 30, 2002):

Smith, E. A., J. Gu, and J. Nickeson. 2001. BOREAS Follow-On HMet-01 Level-2 GOES-8 1996 Shortwave and Longwave Radiation. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

### 20.5 Document Curator:

webmaster@daac.ornl.gov

### 20.6 Document URL:

http://daac.ornl.gov/BOREAS/FollowOn/guides/hmet01_goes8-l2_96_doc.html

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**Keywords:**
GOES-7
GOES-8
Emitted Radiation
Reflected Radiation
Water Vapor

Return to top of document.

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