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BOREAS RSS-18 Level 1B AVIRIS At-Sensor Radiance Imagery

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Documentation Revision Date: 2024-09-30

Dataset Version: 1

Summary

This dataset holds Level 1B (L1B) radiance data collected by the AVIRIS-Classic instrument near Prince Albert, Saskatchewan, Canada, on August 14, 1996. This imagery was acquired for the Boreal Ecosystem-Atmosphere Study (BOREAS) project in the boreal forests of central Canada. BOREAS focused on improving the understanding of exchanges of radiative energy, sensible heat, water, CO₂ and trace gases between the boreal forest and the lower atmosphere. NASA's AVIRIS-Classic is a pushbroom spectral mapping system with high signal-to-noise ratio (SNR), designed and tolerated for high performance spectroscopy. AVIRIS-Classic measures reflected radiance in 224 contiguous bands at approximately 10-nm intervals in the Visible to Shortwave Infrared (VSWIR) spectral range from 400-2500 nm. The AVIRIS-Classic sensor has a 1 milliradian instantaneous field of view, providing altitude dependent ground sampling distances from 20 m to sub meter range. For these data, AVIRIS-Classic was deployed on NASA's ER-2 high altitude aircraft. These spectra are acquired as images with 20-meter spatial resolution, 11 km swath width, and flight lines up to 800 km in length. The measurements are spectrally, radiometrically, and geometrically calibrated. There are seven flight lines subdivided into 66 scenes. The dataset includes the radiance imagery cube for each scene along with calibration and navigation information. The radiance data are in instrument coordinates, georeferenced by center of each scan line, and provided in a binary file. Metadata are included in a mixture of binary and text file formats.

There are 401 files that include radiance data in binary format and metadata in binary and text formats.



Figure 1. False color image of AVIRIS-Classic scene acquired over Waskesiu Lake, north of Prince Albert, Saskatchewan, Canada, on 1996-08-14. Flight: f960814t01, run 01, scene 07; latitude 53.9709, longitude -106.3295. Image shows channels 128 (1563 nm), 33 (666 nm), and 10 (458 nm) as red, green, and blue, respectively.

Citation

Green, R.O., and J.A. Newcomer. 1999. BOREAS RSS-18 Level 1B AVIRIS At-Sensor Radiance Imagery. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/449>

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1. Dataset Overview

This dataset holds Level 1B (L1B) radiance data collected by the AVIRIS-Classic instrument near Prince Albert, Saskatchewan, Canada, on August 14, 1996. This imagery was acquired for the Boreal Ecosystem-Atmosphere Study (BOREAS) project in the boreal forests of central Canada. BOREAS focused on improving the understanding of exchanges of radiative energy, sensible heat, water, CO₂ and trace gases between the boreal forest and the lower atmosphere. NASA's AVIRIS-Classic is a pushbroom spectral mapping system with high signal-to-noise ratio (SNR), designed and toleranced for high performance spectroscopy. AVIRIS-Classic measures reflected radiance in 224 contiguous bands at approximately 10-nm intervals in the Visible to Shortwave Infrared (VSWIR) spectral range from 400-2500 nm. The AVIRIS-Classic sensor has a 1 milliradian instantaneous field of view, providing altitude dependent ground sampling distances from 20 m to sub meter range. For these data, AVIRIS-Classic was deployed on NASA's ER-2 high altitude aircraft. These spectra are acquired as images with 20-meter spatial resolution, 11 km swath width, and flight lines up to 800 km in length. The measurements are spectrally, radiometrically, and geometrically calibrated. There are seven flight lines subdivided into 66 scenes. The dataset includes the radiance imagery cube for each scene along with calibration and navigation information. The radiance data are in instrument coordinates, georeferenced by center of each scan line, and provided in a binary file. Metadata are included in a mixture of binary and text file formats.

Project: Boreal Ecosystem-Atmosphere Study ([BOREAS](#))

The Boreal Ecosystem-Atmosphere Study (BOREAS) was a large-scale international interdisciplinary experiment in the boreal forests of central Canada. Its focus was improving our understanding of the exchanges of radiative energy, sensible heat, water, CO₂ and trace gases between the boreal forest and the lower atmosphere. A primary objective of BOREAS was to collect the data needed to improve computer simulation models of the important processes controlling these exchanges so that scientists can anticipate the effects of global change on the biome. A BOREAS follow-on project extended and built upon the original research efforts.

Related Publications:

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: Atmospheres* 102:28731–28769. <https://doi.org/10.1029/97JD03300>

MacPherson, J. I. 1998. Correction to "BOREAS in 1997: Experiment Overview, Scientific Results, and Future Directions." *Journal of Geophysical Research: Atmospheres* 103:6245–6245. <https://doi.org/10.1029/98JD00396>

Related Datasets: Additional datasets are available on the [BOREAS project page](#).

2. Data Characteristics

Spatial Coverage: Saskatchewan, Canada

Spatial Resolution: nominal 20 m

Temporal Coverage: 1996-08-14

Temporal Resolution: Seven flights conducted on the same day.

Study Areas: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Saskatchewan, Canada	-106.4932	-105.0253	54.3169	53.4513

Data File Information

There are 401 files that include radiance data in binary format and metadata in binary and text formats. The files hold data for seven flight lines; radiance data are provided in 66 scenes distributed along these flight lines (Figure 2). While some files provide information for the entire flightline (Table 1), others hold data for individual scenes within a flightline (Table 2).

File naming conventions:

Files pertaining to entire flightlines: *f960814t01p02_r<run>.c.<ext>*

Scene-specific files: *f960814t01p02_r<run>_s<scene>.c.<ext>*

Binary radiance files: *f960814t01p02_r<run>_sc<scene>.c.img*

- *f960814t01p02* = the AVIRIS-Classic flight ID that encodes the date as YYYYMMDD (same for all files)
- *<run>* = two-digit run ID that designates the separate flightlines (e.g., "01" to "07")
- *<scene>* = two-digit number identifying scenes within a flightline (e.g., "01" to "11")
- *<ext>* = suffix to indicate file type (Tables 1 and 2)

The file *BOREAS_RSS_AVIRIS_readme.txt* holds additional metadata and notes about these files. It is included as a data file and a companion file. *BOREAS_project_info.txt* is an additional companion file with general information about the BOREAS project.

Table 1. Information for files pertaining to entire flightlines.

File content	Suffix	Format*	Description
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General information	.avhdr	text	Information about flight and acquisition of AVIRIS data
Browse image	.brz	Int16, BIP	Binary image with dimensions of (4 channels x 614 samples x NL), where NL = number of lines. The AVIRIS-Classic channels are 10, 33, 128, and 192. To calculate the number of lines, divide the file size by 4912 bytes per line. (4 x 614 x 2 bytes per pixel = 4912)
Radiance multiplication factors (gain)	.gain	text	Multiplication factors (gain) to convert radiance as 16-bit integers. Two columns: (a) multiplication factor, (b) channel number. When each spectrum in the radiance image is divided by these factors, the 16-bit integers are converted to radiance in units of microwatts $\text{cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$.
Geometric calibration	.geo	text	Spatial resolution on the ground. Five columns: (a) Spatial sampling interval (pixel center to center distance on the ground), (b) Spatial response function (the FWHM of the spatial response function assumed to be Gaussian); this is a measure of the nominal pixel size), (c) Spatial sampling interval uncertainty, (d) Spatial response function uncertainty, (e) Channel number. Units for (a) - (d) are milliradians.
Processing log information	.log	text	Date when the AVIRIS data were processed for distribution, number of lines in the flight line, number of scenes in the flight line, and number of lines in the last scene.
On-board calibration correction coefficients	.occ	text	Coefficients used in radiometric calibration. Two columns: (a) on-board calibration correction coefficient, (b) channel number.
Post-flight on-board calibrator data	.post	Int16, BIP	Data from the on-board calibrator after the flight line. Dimensions: 224 channels x 614 samples x 8 bands. Eight bands: (a) Dark signal one side of shutter, (b) Dark signal other side of shutter, (c) Spectral filter A one side of shutter, (d) Spectral filter A other side of shutter, (e) Spectral filter B one side of shutter, (f) Spectral filter B other side of shutter, (g) High signal one side of shutter, (h) High signal other side of shutter.
Pre-flight on-board calibrator data	.pre	Int16, BIP	Data from the on-board calibrator before the flight line. Dimensions: 224 channels x 614 samples x 8 bands. Eight bands: (a) dark signal one side of shutter, (b) dark signal other side of shutter, (c) spectral filter A one side of shutter, (d) spectral filter A other side of shutter, (e) spectral filter B one side of shutter, (f) spectral filter B other side of shutter, (g) High signal one side of shutter, (h) High signal other side of shutter.
Radiometric calibration coefficients	.rcc	text	AVIRIS radiometric calibration coefficients and laboratory calibration uncertainty. Three columns: (a) radiometric calibration coefficients, (b) uncertainty in radiometric calibration, (c) Channel number. Units for (a) and (b) are microwatts $\text{cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$
Spectral calibration	.spc	text	AVIRIS spectral calibration. Five columns: (a) wavelength center position, (b) full width at half maximum (FWHM) for equivalent Gaussian, (c) uncertainty in wavelength center position, (d) uncertainty in FWHM for equivalent gaussian, (e) Channel number. Units for (a) - (d) are nm.

* Data formats: *text* = ASCII text, *Int16* = binary 16-bit signed integer IEEE, *BIP* = band interleaved by pixel.

Table 2. Information for scene-specific files.

File content	Suffix	Format	Description
Summed dark signal-first part	.drk1	Int16, BIP	First part of summed dark signal (most significant 12 bits) with dimensions 224 channels x 1 sample, x 512 lines. Last scene in flightlines may have <512 lines. To calculate number lines, divide file size by 448 bytes per line.
Summed dark signal-second part	.drk2	Int16, BIP	Second part of summed dark signal (most significant 12 bits) with dimensions 224 channels x 1 sample, x 512 lines. Last scene in flightlines may have <512 lines.
Engineering data	.eng	Int16	Engineering data in minor frame 2 format using 12-bit words. See file <i>BOREAS_RSS_AVIRIS_readme.txt</i> for a complete list of the 224 word groups.
Navigation data	.nav	text	Navigation data with GPS coordinates, aircraft platform states, and weather data. There is one line of navigation data for each scan line in the scene. Each line holds values for 29 parameters. See <i>BOREAS_RSS_AVIRIS_readme.txt</i> for a complete list of parameters with units and data formats.
Calibrated radiance image cube	.img	Int16, BIP	Calibrated radiance multiplied by <i>gain</i> and stored as 16-bit integers. Units are (gain) x (microwatts $\text{cm}^{-2} \text{nm}^{-1} \text{sr}^{-1}$). Dimensions are 224 channels x 614 samples x 512 scan lines. The last scene in flight line may have <512 lines. To calculate the number of lines divide the file size by 275,072 bytes per line.

3. Application and Derivation

AVIRIS-Classic spectral images record the interaction of atmospheric and surface matter with the solar reflected spectrum through processes

of absorption and scattering. Analysis of the measured radiance spectra enables determination of atmospheric and surface constituents. Many of the questions posed in BOREAS are related to the distribution and change of constituents of the atmosphere and surface.

With an accurate calibration, AVIRIS radiance data may be analyzed quantitatively to retrieve surface reflectance and derived atmospheric and ecological parameters using radiative transfer codes. Accurate calibration allows comparison of data acquired at the different BOREAS sites and through a time series.

4. Quality Assessment

Spectral and radiometric calibrations are determined for AVIRIS at the Jet Propulsion Laboratory prior to each period of operations. The instrument includes an on-board calibrator that provides calibration data before and after each flight. In addition, the AVIRIS sensor and on-board calibrator are calibrated in the laboratory before and after each flight season. During laboratory calibration, the spectral, radiometric and geometric characteristics of AVIRIS are determined with respect to laboratory standards.

The spectral calibration was within 5% in both spectral channel position and spectral response function full-width half maximum (FWHM). The radiometric calibration was assessed at better than 5%. The geometric calibration is assessed to be at the 7% of the reported along track and cross track spatial response function.

There is a recognized slew effect in the AVIRIS detector array readout expressed as a slight shift in the spatial resolution (instantaneous field of view, IFOV) when moving from regions of very different brightnesses.

5. Data Acquisition, Materials, and Methods

AVIRIS-Classic measures the total incident spectral radiance from 400 to 2500 nm through 224 channels at nominally 10 nm spectral sampling and response function (Green et al., 1998). There are 614 cross-track elements (samples) per scan line. The images were stored in their raw spatial form with pixel size increasing from nadir to the scanning extremes of 15 degrees. The instrument includes an on-board calibrator that provides calibration data before and after each flight. In addition, the AVIRIS sensor and on-board calibrator are calibrated in the laboratory before and after each flight season. During laboratory calibration the spectral, radiometric and geometric characteristics of AVIRIS are determined with respect to laboratory standards. Calibration information is included in this dataset (Table 1).

These BOREAS data were acquired under largely clear sky conditions on August 14, 1996. The instrument was deployed on a NASA ER-2 aircraft from altitude of 19,800 m. At this altitude, the nominal spatial resolution was 20 m and the swath width was approximately 10.8 km. The ER-2 flew seven flightlines totaling about 800 km over the Prince Albert National Park, Wakesiu Lake, and Candle Lake regions north of Prince Albert, Saskatchewan, Canada.

The raw imagery data were spectrally, radiometrically, and geometrically calibrated by the BOREAS Remote Sensing Science Team 18 (RSS-18) at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL). For each flight line, a multiplication factor was applied to each channel to convert the radiance values to 16-bit integers; these factors are included in the *.gain file for flightline. The user may divide the Int16 numbers in the *.img files by these channel-specific gain factors to convert values to radiance units ($\mu\text{W cm}^{-2} \text{ nm}^{-1} \text{ sr}^{-1}$).

The radiance data from the seven flight lines were divided into 66 scenes. Each scene is approximately 10 km x 11 km in area and typically holds 512 scan lines of data, although the final scene on a flightline may have <512 lines. These radiance data are not orthorectified and are provided in instrument coordinates. The center of each scan line is georeferenced by geographic coordinates provided in the navigation (*.nav) file for each scene. Each scene has five files (Table 2); the .img file has the calibrated radiance image data.

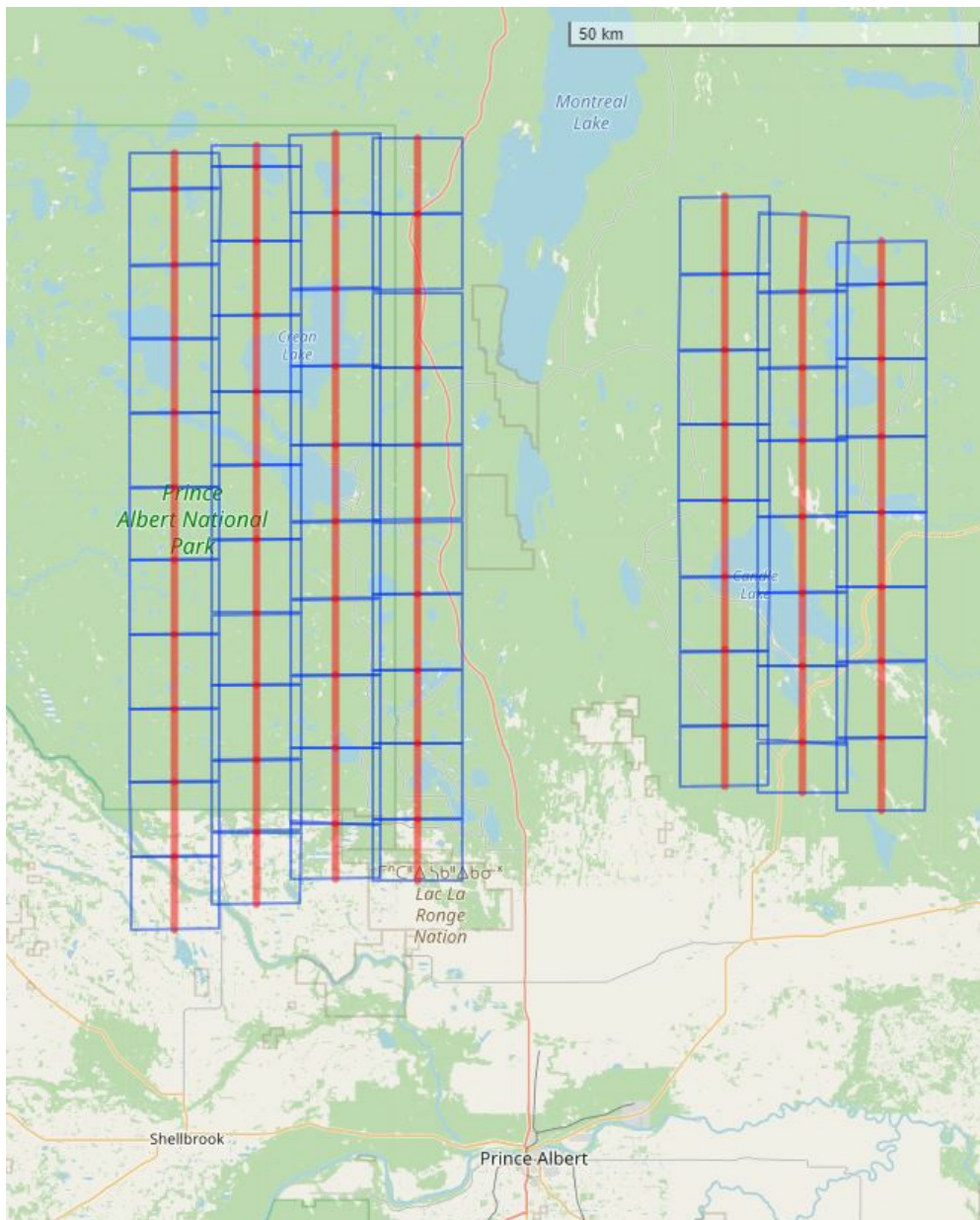


Figure 2. Location of seven flight lines (red) north of Prince Albert, Saskatchewan, Canada. Blue rectangles show the approximate footprints of imagery scenes distributed along these flight lines. The scenes are 10.8 km in east-west dimension.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[BOREAS RSS-18 Level 1B AVIRIS At-Sensor Radiance Imagery](#)

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Green, R.O., M.L. Eastwood, C.M. Sarture, T. G. Chrien, M. Aronsson, B.J. Chippendale, J.A. Faust, B.E. Pavri, C. J. Chovit, M. Solis, M.R. Olah, and O. Williams. 1998. Imaging Spectroscopy and the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). *Remote Sensing of Environment* 65:227- 248. [https://doi.org/10.1016/S0034-4257\(98\)00064-9](https://doi.org/10.1016/S0034-4257(98)00064-9)

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8. Dataset Revisions

Version	Release Date	Revision Notes
	2024-09-30	All data files were replaced and user guide updated.
1.0	1999-11-16	Original publication



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