SHIFT: AVIRIS-NG L1B Calibrated Radiance, V2

Get Data

Documentation Revision Date: 2025-09-16

Dataset Version: 2

Summary

This dataset contains Level 1B (L1B) unrectified calibrated surface radiance images as well as files of observational geometry and illumination parameters and supporting sensor band information from NASA's Airborne Visible / Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) instrument. This imagery was collected at regular (approximately weekly) intervals in 2022 between February and May, as well as in September as part of the Surface Biology and Geology High-Frequency Time Series (SHIFT) campaign. The SHIFT campaign leveraged NASA's AVIRIS-NG facility instrument to collect VSWIR data at approximately a weekly cadence across a broad study area, enabling traceability analyses related to the science value of VSWIR revisits. This campaign will generate precise, high-frequency data on plant communities collected over nearly 1,656 square kilometers across Santa Barbara County, California, US, and nearby coastal Pacific waters. AVIRIS-NG is a pushbroom spectral mapping system with high signal-to-noise ratio (SNR), designed and toleranced for high performance spectroscopy. AVIRIS-NG measures reflected radiance at 5-nm intervals in the Visible to Shortwave Infrared (VSWIR) spectral range from 380-2510 nm. The AVIRIS-NG sensor has a 1 milliradian instantaneous field of view, providing altitude dependent ground sampling distances from 20 m to sub-meter range. In this dataset, for each flight line, the data include: orthocorrected calibrated radiance imagery, geometric lookup table, observation geometry and illumination information, input geometry, and orthocorrected locations of each pixel.These AVIRIS-NG L1B data are provided in netCDF format along with RGB quicklook images in TIFF image format.

This dataset includes calibrated radiance data for 1598 flight scenes.

Figure 1. Portion of quicklook image for AVIRIS-NG flight ang20220228t214527 over Ventura County north of Santa Clara River west of Fillmore, California on 28 February 28 2022. Approximately 34.403 latitude, -118.990 longitude.

Citation

Brodrick, P.G., R. Eckert, A.M. Chlus, J.W. Chapman, R. Pavlick, M. Bernas, M. Helmlinger, M. Hess-Flores, L.M. Rios, F.D. Schneider, M.M. Smyth, M. Eastwood, R.O. Green, D.R. Thompson, K.D. Chadwick, and D.S. Schimel. 2025. SHIFT: AVIRIS-NG L1B Calibrated Radiance, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2432

Table of Contents

1. Dataset Overview

This dataset contains Level 1B (L1B) unrectified calibrated surface radiance images as well as files of observational geometry and illumination parameters and supporting sensor band information from NASA's Airborne Visible / Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) instrument. This imagery was collected at regular (approximately weekly) intervals in 2022 between February and May, as well as in September as part of the Surface Biology and Geology High-Frequency Time Series (SHIFT) campaign. The SHIFT campaign leveraged NASA's AVIRIS-NG facility instrument to collect VSWIR data at approximately a weekly cadence across a broad study area, enabling traceability analyses related to the science value of VSWIR revisits. This campaign will generate precise, high-frequency data on plant communities collected over nearly 1,656 square kilometers across Santa Barbara County, California, US, and nearby coastal Pacific waters.

AVIRIS-NG is a pushbroom spectral mapping system with high signal-to-noise ratio (SNR), designed and toleranced for high performance spectroscopy.

AVIRIS-NG measures reflected radiance at 5-nm intervals in the Visible to Shortwave Infrared (VSWIR) spectral range from 380-2510 nm. The AVIRIS-NG sensor has a 1 milliradian instantaneous field of view, providing altitude dependent ground sampling distances (GSD) from 20 m to sub-meter range; in this dataset, most light lines are at approximately 5 m GSD, with a few higher resolution lines included. In this dataset, for each flight line, the data include: orthocorrected calibrated radiance imagery, geometric lookup table, observation geometry and illumination information, input geometry, and orthocorrected locations of each pixel.

Project: Surface Biology and Geology High-Frequency Time Series (SHIFT)

The Surface Biology and Geology (SBG) High Frequency Time Series (SHIFT) was an airborne and field campaign during February to May, 2022, with a follow up activity for one week in September, in support of NASA's SBG mission. Its study area included a 640-square-mile (1,656-square-kilometer) area in Santa Barbara County and the coastal Pacific waters. The primary goal of the SHIFT campaign was to collect a repeated dense time series of airborne Visible to ShortWave Infrared (VSWIR) airborne imaging spectroscopy data with coincident field measurements in both inland terrestrial and coastal aquatic areas, supported in part by a broad team of research collaborators at academic institutions. The SHIFT campaign leveraged NASA's Airborne Visible-Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) facility instrument to collect approximately weekly VSWIR imagery across the study area. The SHIFT campaign 1) enables the NASA SBG team to conduct traceability analyses related to the science value of VSWIR revisit without relying on multispectral proxies, 2) enables testing algorithms for consistent performance over seasonal time scales and end-to-end workflows including community distribution, and 3) provides early adoption test cases to SHIFT application users and incubate relationships with basic and applied science partners at the University of California Santa Barbara Sedgwick Reserve and The Nature Conservancy's Jack and Laura Dangermond Preserve.

Related Datasets

Bohn, N., P.G. Brodrick, D.R. Thompson, R. Eckert, and P. Lovegreen. 2023. SHIFT: AVIRIS-NG Derived Gridded Mosaicked Canopy Water Content, California, 2022. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2242

Brodrick, P.G., R. Pavlick, M. Bernas, J.W. Chapman, R. Eckert, M. Helmlinger, M. Hess-Flores, L.M. Rios, F.D. Schneider, M.M. Smyth, M. Eastwood, R.O. Green, D.R. Thompson, K.D. Chadwick, and D.S. Schimel. 2023. SHIFT: AVIRIS-NG L1A Unrectified Radiance. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2184

- Version 1 of this dataset holding L1A radiance files.

Brodrick, P., R. Pavlick, M. Bernas, J.W. Chapman, R. Eckert, M. Helmlinger, M. Hess-Flores, L.M. Rios, F.D. Schneider, M.M. Smyth, M. Eastwood, R.O. Green, D.R. Thompson, K.D. Chadwick, and D.S. Schimel. 2023. SHIFT: AVIRIS-NG L2A Unrectified Reflectance. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2183

- Version 1 of L2A surface reflectance data derived from V1 L1A radiance (Brodrick et al., 2023a)

Brodrick, P.G., A. Chlus, R. Pavlick, M. Bernas, J.W. Chapman, R. Eckert, M. Helmlinger, M. Hess-Flores, L.M. Rios, F.D. Schneider, M.M. Smyth, M. Eastwood, R.O. Green, D.R. Thompson, K.D. Chadwick, and D.S. Schimel. 2025. SHIFT: AVIRIS-NG L2A Orthorectified Surface Reflectance, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2431

- Version 2 of L2A surface reflectance derived from calibrated radiance in this dataset.

Green, R.O., P.G. Brodrick, J.W. Chapman, M. Eastwood, S. Geier, M. Helmlinger, S.R. Lundeen, W. Olson-Duvall, R. Pavlick, L.M. Rios, D.R. Thompson, and A.K. Thorpe. 2023. AVIRIS-NG L1B Calibrated Radiance, Facility Instrument Collection, V1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2095

Acknowledgement

SHIFT is jointly led by NASA’s Jet Propulsion Laboratory, The Nature Conservancy, and the University of California, Santa Barbara (UCSB).

2. Data Characteristics

Spatial Coverage: Santa Barbara County, California and nearby Pacific Ocean

Spatial Resolution: Varies with aircraft altitude; typically 4.8 m

Temporal Coverage: 2022-02-24 to 2022-09-15

Temporal Resolution: Approximately weekly flights over study area during February - May and in September 2022.

Study Area: (All latitudes and longitudes given in decimal degrees)

Study Area	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Santa Barbara County, California and nearby Pacific Ocean	-120.643	-118.035	35.116	33.904

Data File Information

This dataset includes calibrated radiance and observational parameters in netCDF format, quicklook images as GeoTIFFs, and processing information in text-based YAML format. There are data for 1598 flight scenes.

The naming convention for the files is *<flight prefix>_<id>_<level>_<ver>_<product>.<ext>*, where

- <flight prefix> = flight line identifier, *angYYYYMMDDthhmmss*, encoding the date and time by year (YYYY), month (MM), day (DD), hour (hh), minute (mm), and second (ss) of the flight (e.g., ang20220915t213504).
- <id> = scene-id from within a flight line
- <level> = data level: “L1B” for NASA Earth Science Community Data Processing Level 1B. "ORT" for orthocorrected, "RDN" for radiance.
- <ver> = unique seven character identifier of full heritage versioning.
- <product> = Level 1B data product: “RDN" for radiance, “OBS" for orthocorrected observational parameters, “RDN” for radiance, "BANDMASK" for denoting interpolated wavelengths.
- <ext> = file extension indicating file type: “nc” for netCDF, “tif” for GeoTIFF, “yaml” for YAML text file.

Example file names for scene 002 from the flight line ang20220915t213504 are:

- ang20220915t213504_002_L1B_ORT_fb37be20_OBS.nc
- ang20220915t213504_002_L1B_ORT_fb37be20.yaml
- ang20220915t213504_002_L1B_RDN_a2a7e733_BANDMASK.nc
- ang20220915t213504_002_L1B_RDN_a2a7e733_RDN.nc
- ang20220915t213504_002_L1B_RDN_a2a7e733_RDN.tif
- ang20220915t213504_002_L1B_RDN_a2a7e733.yaml

There are six files for each flight scene packaged for convenience as a collection of several related files that can be treated as a single, downloadable unit. The naming system for the unique identifier for the package is **AVIRIS-NG_SHIFT_V2_L1B_<flight prefix>_<id>_RDN**. This unique identifier can be used to locate and retrieve respective individual files in the NASA Earthdata Search UI and within the NASA Common Metadata Repository (CMR) API.

The radiance (RDN) files hold calibrated radiance in raw spatial format (not orthocorrected). However, both the RDN and ORT files include the geometric lookup table (GLT), which provides a georeferenced location for each pixel in the raw image (Table 3). The GLT is an orthocorrected product with a fixed pixel size projected into a UTM coordinate system that contains the information about which original pixel occupies which output pixel in the final product. Orthocorrected pixels are referenced back to the raw image by the *line* and *sample* variables. The *line* and *sample* values are sign-coded to indicate if it is a real measurement (indicated by a positive value) or a nearest-neighbor infill (indicated by negative values).

The band mask (BANDMASK) files indicate for each pixel whether a given wavelength was interpolated. Interpolation occurred due to a bad pixel in the focal plane array or from saturation. The per pixel data is provided as a bit-packed unsigned integer array with dimensions of *lines* x *samples*, organized across 54 *layers*. There is one value per pixel for each of 425 wavelengths, ordered from shortest to longest wavelength. Each layer holds the mask values for eight wavelengths, except that the last layer (54) holds mask values for the longest wavelength. For each pixel in a given layer, the bit-packed value is an unsigned integer, ranging 0 to 255, that indicates which of eight wavelengths were interpolated. The integer value represents a boolean vector of eight bits (Table 4); each bit corresponds to a wavelength. An integer value of 0 (also the nodata value) indicates that no wavelengths were interpolated. The value of 1 indicates that the first wavelength was interpolated and the remaining seven were not. A 3 indicates that only the first and second wavelengths were interpolated. See Table 4 for more examples.

Table 1. Variables in calibrated radiance (RDN) netCDF files.

Variable	Description	Units
radiance	Calibrated radiances in 425 bands covering wavelengths between 390 nm to 2510 nm in approximately 5-nm intervals. Image cube dimensions = lines x samples x 425 bands	uW nm^{-1} cm^{-2} sr^{-1}
wavelength	Center wavelength for each spectral band (n = 425)	nm
fwhm	Full width at half maximum for band (n = 425)	nm

Table 2. Variables in Level 1B observational parameters (ORT) netCDF files. These parameters are in the raw spatial format matching the corresponding unorthocorrected radiance image. Pixels are referenced by the *line* and *sample* variables. Use the geometric lookup table to find the georeferenced location for each pixel.

Variable	Description	Units
path_length	Sensor-to-ground distance	m
to_sensor_azimuth	Sensor azimuth angle; 0 to 360 degrees clockwise from north	degrees
to_sensor_zenith	Sensor zenith angle; 0 to 90 degrees from zenith	degrees
to_sun_azimuth	Solar azimuth angle; 0 to 360 degrees clockwise from north	degrees
to_sun_zenith	Solar zenith angle; 0 to 360 degrees clockwise from north	degrees
solar_phase	Solar phase; degrees between to-sensor and to-sun vectors in principal plane	degrees
slope	Local surface slope as derived from DEM in degrees	degrees
aspect	Local surface aspect 0 to 360 degrees clockwise from N	degrees
cosine_i	Apparent local illumination factor based on DEM slope and aspect and to sun vector; range -1.0 to 1.0	1
utc_time	Decimal hours since 2023-07-11 00:00:00Z for mid-line pixels	h
earth_sun_distance	Earth-to-sun distance in astronomical units	au

Table 3. Geolocation variables in both radiance (RDN) and observational parameters (ORT) netCDF files. Coordinates use the WGS 84 ellipsoid.

Variable	Description	Units
easting	UTM easting coordinate for center of grid cell for orthocorrected pixel location	m
northing	UTM northing coordinate for center of grid cell for orthocorrected pixel location	m
transverse_mercator	Details about the projected UTM coordinate system in well-known text (WKT) format.	-
lon	Longitude for center of grid cell; EPSG 4326	degrees east
lat	Latitude for center of grid cell; EPSG 4326	degrees north
elev	Elevation for center of grid cell in height above mean sea level (surface elevation)	m
line	Pixel identifier in the along-track (flight path) direction, indicating the row location of a pixel from the uncorrected sensor image within the orthocorrected grid.	1

sample	Pixel identifier in the across-track direction, indicating the column location of a pixel from the uncorrected sensor image within the orthocorrected grid.	1

Table 4. Bit-packing scheme employed in band mask (BANDMASK) files that uses integer values to indicate which of eight wavelengths were interpolated; channel numbers for the given byte start at 8 times the number of previous bytes (e.g., byte 3 starts with 1-based index channel 17). Byte values range from 0 to 255. This table provides selected examples and does not illustrate all possible values. "-" = not interpolated.

	Wavelength interpolated							
Value	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0	-	-	-	-	-	-	-	-
1	yes	-	-	-	-	-	-	-
2	-	yes						
3	yes	yes	-	-	-	-	-	-
4	-	-	yes	-	-	-	-	-
9	yes	-	-	yes	-	-	-	-
16	-	-	-	-	yes	-	-	-
25	yes	-	-	yes	yes	-	-	-
36	-	-	yes	-	-	yes	-	-
64	-	-	-	-	-	-	yes	-
128	-	-	-	-	-	-	-	yes
239	yes	yes	yes	yes	-	yes	yes	yes
255	yes	yes	yes	yes	yes	yes	yes	yes

3. Application and Derivation

A primary goal of the SHIFT campaign was to collect a repeated dense time series of airborne Visible to ShortWave Infrared (VSWIR) airborne imaging spectroscopy data with coincident field measurements in both inland terrestrial and coastal aquatic areas. The AVIRIS-NG instrument collects VSWIR data that will be combined with in-situ measurements of plant diversity and ecophysiology to produce weekly estimates of ecosystem function over the 1,656-km^2 study area.

These data document seasonal progressions in these ecosystems. Sampling intervals must be short enough to capture subseasonal changes in phenology with associated changes in ecosystem states and functions. Moreover, the changes occur on varying schedules in terrestrial versus aquatic systems and are influenced by spatial heterogeneity in geology, topography, and ocean currents.

Hyperspectral AVIRIS-NG data provide information on ecosystem functions such as water use. For example, to estimate canopy water content, in-situ measurements of plant water status and leaf spectra were taken >100 native oak (*Quercus* spp.) trees concurrent with AVIRIS-NG flights. These field data were used to calibrate the relationship between field conditions and hyperspectral imagery. Once known, these models can be applied across the landscape on a given date.

Obtaining global VSWIR observations on a 16-day return interval is one of the technological design challenges of the SBG mission. The high time frequency VSWIR data collected by SHIFT provides the opportunity to evaluate the information gained by high revisit rates and check the stability of analytical algorithms over the seasonal time series.

4. Quality Assessment

The AVIRIS-NG calibration procedure addresses electronic effects involving radiometric responses of each detector, optical effects involving the spatial and spectral view of each detector, and radiometric calibration. Detector responsiveness is measured at the beginning of each deployment and mid-flight for particularly long deployments. Instrument artifacts in the spectrometer data, such as striping, are removed statistically by minimizing a Markov Random Field model. Likewise, bad pixels are identified and corrected using statistical methods followed by laboratory and field protocols to evaluate effectiveness. Details of calibration methods are available in Chapman et al. (2019).

5. Data Acquisition, Materials, and Methods

As a key component of the SBG High Frequency Time Series (SHIFT) campaign, VSWIR data was collected by the Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG) weekly across the Mediterranean terrestrial and aquatic environments in Santa Barbara County, California. The study area for the SHIFT campaign covers 1,656 km^2 in the vicinity of Santa Barbara, California, US. It stretches from Los Padres National Forest in the east, westward to the Central California coast, and into the coastal ocean (Figure 2).

The Airborne Visible-Infrared Imaging Spectrometer (AVIRIS-NG) was developed to provide continued access to high signal-to-noise ratio imaging spectroscopy measurements in the solar reflected spectral range (Green et al., 1998). AVIRIS-NG data were calibrated from raw digital numbers to at-sensor radiance following methods of Chapman et al. (2019). The process addresses both electronic and optical effects, and calibrates the data to units of $\mu W\ nm^{-1}\ cm^{-2}\ sr^{-1}$.

Pixels were georeferenced using methods developed for the Earth Surface Mineral Dust Source Investigation (EMIT; EMIT L1B ATBD; Thompson et al., 2024). The process used the automated generation of ground control points (GCPs) referenced to a Landsat 8 basemap (https://github.com/emit-sds/emit-sds-l1b-geo). These GCPs were then used to estimate the VSWIR geometric camera model, along with the attitude and ephemeris of the aircraft. This georeferencing method identified the location of each pixel and generated observation view angles, which were used in the surface and atmospheric modeling. The mean georeferencing error was about half a pixel. Some deviations through time were still observable, which were most likely

due to digital surface model inaccuracies.

This Level 1B dataset contains two separate netCDF files: radiance (RDN) and observation parameters (OBS). The radiance file contains calibrated at-sensor radiance measurements in uW nm^{-1} cm^{-2} sr^{-1}, while the observational parameters netCDF file contains viewing and solar geometries, timing, topographic, and other information about the observation. Both radiance and observational parameters files contain a geometric lookup table (GLT), a dataset that links relative row and column reference locations (via *line* and *sample* variables) with the orthocorrected latitude, longitude and elevation for each pixel. Pixel locations are also provided in projected UTM coordinates. Each image line of the Level 1B data product is also UTC time-tagged. Nodata values are set to -9999.

Version 2 of these data leveraged a revised version of the Airborne Science Data System, which utilizes code similar to that from the EMIT mission (https://github.com/emit-sds/emit-sds-l1b), although the process described in Chapman et al. (2019) remains the best description of the AVIRIS-NG calibration. Geolocation for Version 2 has been updated to use the AVIRIS-NG facility instrument collection tie-point adjustment strategy, which is a more systematic procedure of the strategy prototyped in Version 1 of this dataset. Small pixel-level offsets from Version 1 occur as a consequence. The flight lines have also been divided into “scenes”, each as an individual netCDF file, for a more consistent delivery.

Figure 2. Location of AVIRIS-NG flightlines for SHIFT project in February to May, 2022. Map shows a portion of southern California, US. Footprints of imagery data are shown as blue rectangles. Basemap: © OpenStreetMap contributors.

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6. Data Access

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

SHIFT: AVIRIS-NG L1B Calibrated Radiance, V2

Contact for Data Center Access Information:

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

7. References

Bohn, N., P.G. Brodrick, D.R. Thompson, R. Eckert, and P. Lovegreen. 2023. SHIFT: AVIRIS-NG Derived Gridded Mosaicked Canopy Water Content, California, 2022. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2242

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Thompson, D.R., R.O. Green, and M. Smyth. 2024. EMIT L1B Algorithm: Calibrated Radiance at Sensor: Theoretical Basis. Version 1.3. NASA Jet Propulsion Laboratory, California Institute of Technology; Pasadena, California. https://lpdaac.usgs.gov/documents/1570/EMITL1B_ATBD_v1.pdf

8. Dataset Revisions

Version	Release Date	Revision Notes
2.0	2025-09-16	L1B Calibrated radiance data were generated from raw data using an updated algorithm. Data from flights in September 2022 were added. Files are delivered in netCDF, rather than ENVI, format.
	2024-05-12	The following 46 ENVI header files were revised to correct the UTM zone denoted in the "map info" and "coordinate system" strings. The UTM zone was changed from 10N to 11N. ang20220224t195402_glt.hdr ang20220420t182836_glt.hdr ang20220512t180531_glt.hdr ang20220224t200332_glt.hdr ang20220420t212903_glt.hdr ang20220512t181806_glt.hdr ang20220228t183924_glt.hdr ang20220429t182823_glt.hdr ang20220512t183012_glt.hdr ang20220228t185150_glt.hdr ang20220429t183922_glt.hdr ang20220512t184259_glt.hdr ang20220308t183206_glt.hdr ang20220429t215742_glt.hdr ang20220512t185806_glt.hdr ang20220308t184127_glt.hdr ang20220503t181259_glt.hdr ang20220512t190633_glt.hdr ang20220316t183443_glt.hdr ang20220503t205420_glt.hdr ang20220517t184026_glt.hdr ang20220316t184402_glt.hdr ang20220503t210356_glt.hdr ang20220517t184913_glt.hdr ang20220322t192924_glt.hdr ang20220511t182038_glt.hdr ang20220517t212527_glt.hdr ang20220322t193854_glt.hdr ang20220511t183056_glt.hdr ang20220517t213427_glt.hdr ang20220405t185108_glt.hdr ang20220511t214730_glt.hdr ang20220529t184338_glt.hdr ang20220405t190223_glt.hdr ang20220512t164509_glt.hdr ang20220529t185311_glt.hdr ang20220412t185410_glt.hdr ang20220512t170130_glt.hdr ang20220529t220943_glt.hdr ang20220412t190510_glt.hdr ang20220512t171026_glt.hdr ang20220529t222033_glt.hdr ang20220412t215642_glt.hdr ang20220512t173907_glt.hdr ang20220420t181856_glt.hdr ang20220512t175232_glt.hdr
	2024-01	Files associated with three flight lines not associated with the SHIFT project were deleted from this collection: "ang20220228t214527","ang20220228t215349",and "ang20220308t221613". AVIRIS-NG data from those flight lines are available in the AVIRIS Facility Instrument collection.
1.0	2023-09-14	Version 1, L2A data: https://doi.org/10.3334/ORNLDAAC/2183