

# SHIFT: AVIRIS-NG L2A Orthorectified Surface Reflectance, V2

## Get Data

Documentation Revision Date: 2025-09-16

Dataset Version: 2

## Summary

This dataset contains Level 2A (L2A) orthorectified surface reflectance images from NASA's Airborne Visible / Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) instrument. This imagery was collected approximately weekly 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 ~380-2500 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. For this collection, most data is around 5 m, with some flight lines at finer spatial resolution. For each AVIRIS-NG flight line, two file types are included: orthorectified surface reflectance (RFL\_ORT) and orthorectified reflectance uncertainty (UNC\_ORT) in netCDF format. Both file types include data projected in a UTM coordinate system. In addition, ancillary files for each flight line are provided, including a quick look image in GeoTIFF format and text files in YAML format that document processing algorithms and parameters used during production.

This dataset includes orthorectified surface reflectance data for 1593 AVIRIS-NG flight lines.



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

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## 1. Dataset Overview

This dataset contains Level 2A (L2A) orthorectified surface reflectance images from NASA's Airborne Visible / Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) instrument. This imagery was collected approximately weekly 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 ~380-2500 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. For this collection, most data is around 5 m, with some flight lines at finer spatial resolution.

Version 2 of this dataset leveraged a revised version of the Airborne Science Data System, which utilizes code similar to that from the EMIT mission. 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.

**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**

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>

- Version 2 of L1B radiance files.

**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 to May and in September

**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              | 35.117                | 33.904                |

**Data File Information**

This dataset includes orthorectified surface reflectance data for 1593 flight lines. For each AVIRIS-NG flight line, two file types are included: orthorectified surface reflectance (RFL\_ORT) and orthorectified reflectance uncertainty (UNC\_ORT) in netCDF format. Both file types include data projected in a UTM coordinate system. In addition, ancillary files for each flight line are provided, including a quicklook image in GeoTIFF format and text files in YAML format that document processing algorithms and parameters used during production.

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

- *<flight prefix>* = flight line identifier, *angYYYYMMDDthmmss*, 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: “L2A\_OE” for Level 2A product using optimal estimation (OE) processing algorithm
- *<ver>* = unique seven character identifier of full heritage versioning.
- *<product>* = Level 2A data product: “RFL\_ORT” for surface reflectance and “UNC\_ORT” for reflectance uncertainty.
- *<ext>* = file extension indicating file type: “nc” for netCDF, “tif” for GeoTIFF, “yaml” for YAML text file.

Example file names for scene 002 from AVIRIS-NG flight *ang20220915t213504* are:

- *ang20220915t213504\_002\_L2A\_OE\_f6d5005c\_RFL\_ORT.nc*
- *ang20220915t213504\_002\_L2A\_OE\_f6d5005c\_RFL\_ORT.tif*
- *ang20220915t213504\_002\_L2A\_OE\_f6d5005c UNC\_ORT.nc*
- *ang20220915t213504\_002\_L2A\_OE\_f6d5005c.yaml*

There are four 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\_L2A\_<flight prefix>\_<id>\_RFL*. 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.

**Data File Details**

The surface reflectance (RFL\_ORT) and reflectance uncertainty (UNC\_ORT) files hold orthorectified data projected into the UTM coordinate system using WGS-84 datum. Projection information is included with attributes of the *transverse\_mercator* variable in these files.

The quicklook images (\*\_RFL\_ORT.tif) are GeoTIFFs with three bands (RGB) in projected UTM coordinates.

**Table 1.** Variables in surface reflectance (RFL\_ORT) and reflectance uncertainty (UNC\_ORT) files.

| Variable                        | Description  | Units |
|---------------------------------|--|-------|
| <b>Both RFL_ORT and UNC_ORT</b> |  |       |
| easting                         | UTM easting coordinate for center of grid cell for orthorectified pixel location   | m     |
| northing                        | UTM northing coordinate for center of grid cell for orthorectified pixel location  | m     |
| transverse_mercator             | Spatial reference information for the UTM coordinate reference system used   | -     |
| wavelength                      | Center wavelength for each spectral band (n = 425)   | nm    |
| fwhm                            | Full width at half maximum for band (n = 425)  | nm    |
| <b>RFL_ORT only</b>             |  |       |
| reflectance                     | Surface hemispherical directional reflectance factor in 425 bands covering wavelengths between 380 nm to 2500 nm in approximately 7.4-nm intervals, estimated using an optimal estimation based atmospheric correction algorithm | 1     |
| aerosol_optical_thickness       | Factor measuring absorption or optical pathlength of measured radiance; level of aerosols in atmosphere  | 1     |
| water_vapor                     | Level of water vapor in the atmosphere between sensor and surface measured in linear units of condensed liquid.  | cm    |
| <b>UNC_ORT only</b>             |  |       |
| uncertainty                     | Uncertainty in surface hemispherical directional reflectance given in standard deviation units and estimated using an optimal estimation based atmospheric correction algorithm  | 1     |

### 3. Application and Derivation

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. 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<sup>2</sup> 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<sup>2</sup> 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  $\mu\text{W nm}^{-1} \text{cm}^{-2} \text{sr}^{-1}$ .

This Level 2A collection contains surface reflectance data for 425 bands in orthorectified format. L2A reflectances were derived from the associated [L1B radiance data](#) (Brodrick et al., 2025a). The surface reflectance product (RFL\_ORT) includes the hemispherical-directional reflectance factor for every pixel in the scene. Reflectance is estimated from at-sensor radiance (Level 1B) using an optimal estimation (OE) based atmospheric correction procedure, described in the EMIT Level 2A ATBD (Thompson et al., 2020), implemented via the software package ISOFIT (Brodrick et al., 2025b). Pixel locations are provided in projected UTM coordinates. 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. One to two pixel offsets relative to Version 1 frequently occur as a consequence; typically these manifest as a full scene 'shift' in one direction, as a function to a slightly different attitude or ephemeris solution. The flight lines have also been divided into "scenes", each as an individual netCDF file (as in the facility instrument collection), 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.

## 6. Data Access

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

[SHIFT: AVIRIS-NG L2A Orthorectified Surface Reflectance, V2](#)

Contact for Data Center Access Information:

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

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## 8. Dataset Revisions

| Version | Release Date | Revision Notes  |
|---------|--------------|---|
| 2.0     | 2025-09-16   | These data are orthorectified and distributed in a netCDF format. These L2A data were generated using a more recent version of ISOFIT, as well as an updated set of surface prior covariances. Underlying geolocation data were also slightly offset. Overall, however, the reflectances are broadly consistent with Version 001, and most algorithms are likely to transfer between versions successfully. Files for flights in September 2022 were added. |
|         | 2024-01-23   | 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 <a href="#">AVIRIS Facility Instrument</a> collection.  |
| 1.0     | 2023-09-13   | Version 1: <a href="https://doi.org/10.3334/ORNLDAAC/2183">https://doi.org/10.3334/ORNLDAAC/2183</a>  |



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