# SHIFT: AVIRIS-NG L2A Unrectified Reflectance

Get Data

Documentation Revision Date: 2023-09-14

Dataset Version: 1

## Summary

This dataset contains Level 2A (L2A) unrectified surface reflectance images from NASA's Airborne Visible / Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) instrument. This imagery was collected as part of the Surface Biology and Geology High-Frequency Time Series (SHIFT) campaign which occurred during February to May, 2022, with a follow up activity for one week in September. The SHIFT campaign leveraged NASA's AVIRIS-NG facility instrument to collect approximately weekly VSWIR imagery across the study area enabling traceability analyses related to the science value of VSWIR revisit without relying on multispectral proxies. 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. The AVIRIS-NG L2A data are provided in ENVI binary format, which includes a flat binary file accompanied by a header (.hdr) file holding metadata in text format.

This archive currently includes data from February to May 2022. Additional AVIRIS-NG L2A reflectance data from SHIFT will be added as they become available.

This dataset has a total of 402 data files. There are 201 binary ENVI files with 201 ENVI headers in text format.


Figure 1. Portion of quicklook image for AVIRIS-NG flight ang20220228t214527 over Ventura County north of Santa Clara River west of Filmore, California on 28 February 28 2022. Approximately 34.403 latitude, -118.990 longitude. Source: ang20220228t214527_geo.jpeg

## Citation

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## 1. Dataset Overview

This dataset contains Level 2A (L2A) unrectified surface reflectance images from NASA's Airborne Visible / Infrared Imaging Spectrometer-Next Generation (AVIRIS-NG) instrument. This imagery was collected as part of the Surface Biology and Geology High-Frequency Time Series (SHIFT) campaign which occurred during February to May, 2022, with a follow up activity for one week in September. The SHIFT campaign leveraged NASA's AVIRIS-NG facility instrument to collect approximately weekly VSWIR imagery across the study area enabling traceability analyses related to the science value of VSWIR revisit without relying on multispectral proxies.  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.

This archive currently includes data from February to May 2022. Additional AVIRIS-NG L2A reflectance data from SHIFT will be added as they become available.

**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

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

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 L2 Surface Reflectance, Facility Instrument Collection, V1. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2110

**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**: 4.8 m

**Temporal Coverage**: 2022-02-24 to 2022-05-29

**Temporal Resolution:** Approximately weekly flights over study area

**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 | -120.644 | -117.847 | 34.899 | 33.856 |

**Data File Information**

This dataset includes multiband ENVI binary files (.bin) with associated header (.hdr) files. The ENVI header files hold metadata in text format. This dataset has a total of 402 data files. There are 201 binary ENVI files with 201 ENVI headers in text format.

The naming convention for the ENVI files is *<flight prefix>*_rfl.*<ext>*, where

- <flight prefix> = flight line identifier, *angYYYMMDDthhmmss*, encoding the date and time by year (YYYY), month (MM), day (DD), hour (hh), minute (mm), and second (ss) of the flight (e.g., ang20220224t195402).
- "rfl" refers to calibrated surface reflectance, the L2A data product.
- <ext> = file extension of "bin" denotes ENVI binary data files, while "hdr" denotes the ENVI header files.

The header (.hdr) for each ENVI holds metadata for the binary data file, including:

- number of samples (columns), lines (rows), and bands
- band information
- data type (4 = Float32), interleave type, and byte order
- See https://www.l3harrisgeospatial.com/docs/enviheaderfiles.html for the header format.

**Data File Details**

These L2A reflectance files have 425 bands in ENVI format. For the binary files (.bin), the data type is 32-bit floating point in band-interleaved format. The header files (.hdr) are in text format and include the wavelength for each band as well as the radiance processing version number.

**User Note**: These ENVI files are not georeferenced; they are in unprojected instrument coordinates (samples and lines) that follow the trajectory of the respective flight path. Georeferencing information can be found in the Level 1A *input geometry* (igm) ENVI available in the related L1A dataset. The associated igm product shares the same flight prefix and provides UTM coordinates for each pixel. The UTM zone and datum are listed in the input

geometry product's header file, which includes zone 10N (EPSG: 32610) and zone 11N (EPSG: 32611) for these datasets.

## 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-$km^2$ 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., 2020). 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.

Hemispherical Diffuse Reflectance Factor (HDRF) was estimated using an Optimal Estimation retrieval approach from Thompson et al. (2018), which simultaneously optimizes for the surface reflectance and atmospheric state. The atmospheric state consisted of water vapor and a general scattering aerosol. Surface elevation (or pressure altitude) was also retrieved. The inversion relies on a lookup table of radiative transfer simulations for different atmospheric states. Details are available in Thompson et al. (2022).

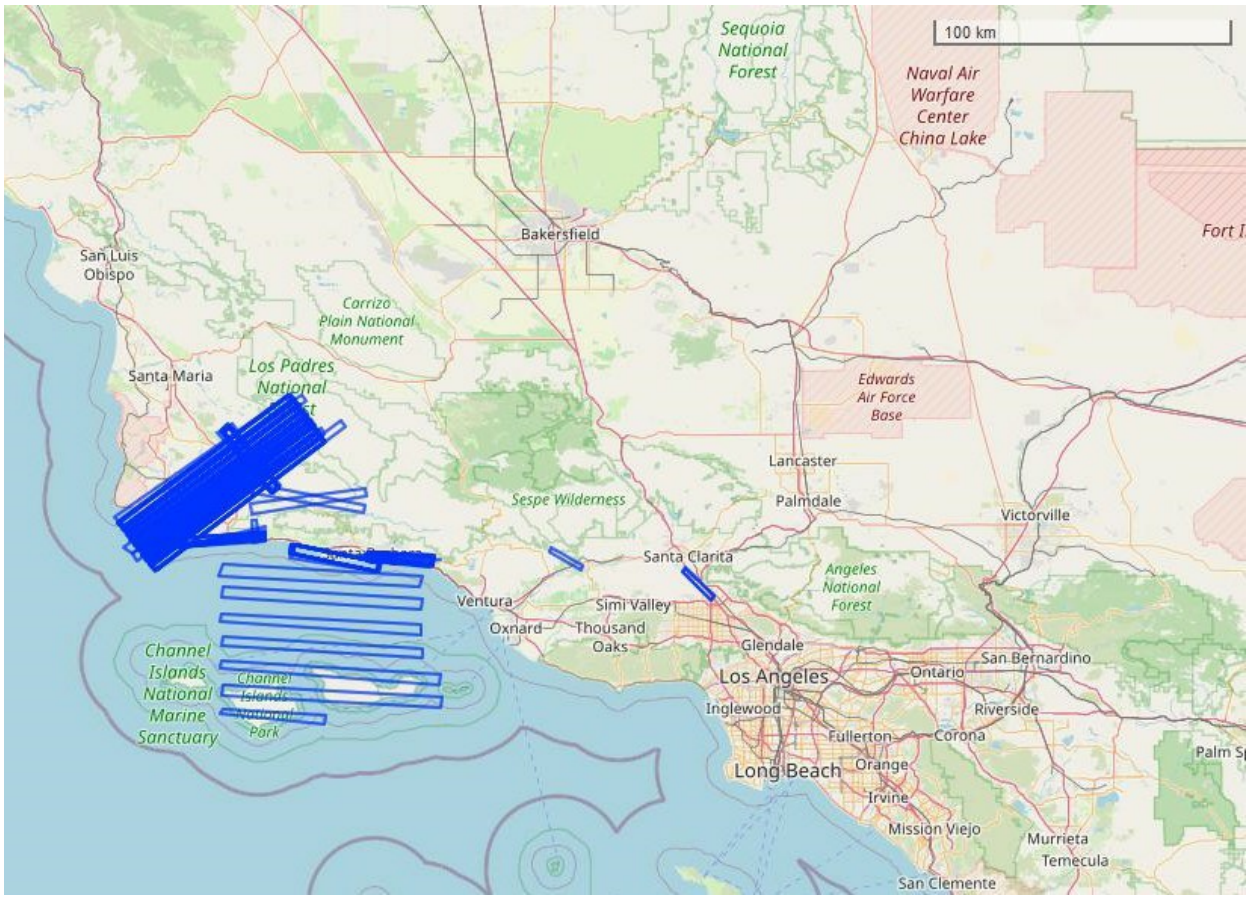


Figure 2. Location of AVIRIS-NG flightlines for SHIFT project in February to May, 2022. Map shows a portion of southern California, US. Footprints of imagery data are shown as blue rectangles.

## 6. Data Access

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

SHIFT: AVIRIS-NG L2A Unrectified Reflectance

Contact for Data Center Access Information:

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

## 7. References


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