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# AVIRIS-3 L2A Orthorectified Surface Reflectance, Facility Instrument Collection

## Get Data

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## Summary

This dataset contains Level 2A (L2A) surface reflectance images from the Airborne Visible / Infrared Imaging Spectrometer-3 (AVIRIS-3) instrument. This is the NASA Earth Observing System Data and Information System (EOSDIS) facility instrument archive of these data. The NASA AVIRIS-3 is a spectral mapping system that measures reflected radiance at 7.4-nm intervals in the Visible to Shortwave Infrared (VSWIR) spectral range from 390-2500 nm. Surface hemispherical directional reflectance was derived from calibrated radiance using an optimal estimation algorithm. For each 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.

The AVIRIS-3 sensor has a 40 degree instantaneous field of view with 1234 pixels, providing altitude dependent ground sampling distances from 20 m to sub meter range. This spectrometer measures radiance from surface and atmosphere and is identical in design to the orbital Earth Surface Mineral Dust Source Investigation (EMIT) spectrometer. AVIRIS-3 has been designed to fly on a variety of aircraft platforms including the King Air B-200, Gulfstream III, Gulfstream V, and ER-2.

Additional AVIRIS-3 facility instrument L2A data will be added as they become available. AVIRIS-3 supports NASA Science and applications in many areas including plant composition and function, geology and soils, wetlands and aquatic ecosystems, greenhouse gas mapping, and calibration of orbital platforms.

NASA facility instruments operate out of a NASA research center and support multiple science disciplines, field investigations, and NASA science objectives. Facility instruments are supported by managers in the Earth Science Division (ESD) Research and Analysis Program, and/or the Earth Observation System (EOS) Project Science Office. The AVIRIS-3 project operates under the Earth Science Airborne Program of the Jet Propulsion Laboratory. In addition to operating and maintaining the sensor, the AVIRIS-3 project works to ensure that experiment requirements are met for each flight and that users are satisfied with data quality and the level of service provided.

This dataset will include all L2A files from the AVIRIS-3 facility instrument.



Figure 1. False color image derived from AVIRIS-3 orthorectified surface reflectance data (R: 1660 nm, G: 850 nm, B: 560 nm) acquired on 2023-07-11 over Palmdale, California (approximately 34.642 latitude, -118.064 longitude); flight AV320230711t225833.

## Citation

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## 1. Dataset Overview

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NASA facility instruments operate out of a NASA research center and support multiple science disciplines, field investigations, and NASA science objectives. Facility instruments are supported by managers in the Earth Science Division (ESD) Research and Analysis Program, and/or the Earth Observation System (EOS) Project Science Office. The AVIRIS-3 project operates under the Earth Science Airborne Program of the Jet Propulsion Laboratory. In addition to operating and maintaining the sensor, the AVIRIS-3 project works to ensure that experiment requirements are met for each flight and that users are satisfied with data quality and the level of service provided.

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### Project: AVIRIS

The Airborne Visible InfraRed Imaging Spectrometer - Classic (AVIRIS-C) and Next Generation (AVIRIS-NG) are two Facility Instruments (FIs) that are part of NASA's Airborne Science Program (ASP) and the Jet Propulsion Laboratory's (JPL) Earth Science Airborne Program. The AVIRIS-C is an imaging spectrometer that delivers calibrated images of the upwelling spectral radiance in 224 contiguous spectral channels with wavelengths from 400 to 2500 nanometers (nm). The AVIRIS-NG is the successor to AVIRIS-Classic and provides high signal-to-noise ratio imaging spectroscopy measurements in 425 contiguous spectral channels with wavelengths in the solar reflected spectral range (380-2510 nm). The AVIRIS-NG started operation in 2014 and is expected to replace the AVIRIS-C instrument. Data from AVIRIS-C and AVIRIS-NG have been applied to a wide range of studies in the fields of terrestrial and coastal aquatic plant physiology, atmospheric and aerosol studies, environmental science, snow hydrology, geology, volcanology, oceanography, soil and land management, agriculture, and limnology.

### Related Publications

Green, R.O., M.E. Schaepman, P. Mouroulis, S. Geier, L. Shaw, A. Hueini, M. Bernas, I. McKinley, C. Smith, R. Wehbe, M. Eastwood, Q. Vinckier, E. Liggett, S. Zandbergen, D. Thompson, P. Sullivan, C. Sarture, B. Van Gorp, and M. Helmlinger. 2022. Airborne Visible/Infrared Imaging Spectrometer 3 (AVIRIS-3). 2022 IEEE Aerospace Conference (AERO). <https://doi.org/10.1109/AERO53065.2022.9843565>

### Related Datasets

Eckert, R., D.R. Thompson, A.M. Chlus, J.W. Chapman, M. Eastwood, M. Bernas, S. Geier, M. Helmlinger, D. Keymeulen, E. Liggett, S. Nadgauda, L.M. Rios, L.A. Shaw, W. Olson-Duvall, P.G. Brodrick, and R.O. Green. 2024. AVIRIS-3 L1B Calibrated Radiance, Facility Instrument Collection. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/2356>

- Level 2 surface reflectance products were developed from these L1B data.

## 2. Data Characteristics

**Spatial Resolution:** 0.5 to 20 m (altitude dependant)

**Temporal Resolution:** One-time estimate

### Data File Information

This dataset includes surface reflectance and surface reflectance uncertainty in netCDF format, quicklook images as GeoTIFFs, and processing information in text-based YAML format.

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

- `<flight prefix>` = flight line identifier, `AV3YYYYMMDDthhmmss`, encoding the date and time by year (YYYY), month (MM), day (DD), hour (hh), minute (mm), and second (ss) of the flight (e.g., `AV320230711t225833`).
- `<id>` = scene-id from within a flight line.
- `<level>` = data level: "L2A" for Level 2A.
- `<ver>` = unique seven character identifier of full heritage versioning.
- `<product>` = Level 2A data product: "RFL\_ORT" for surface reflectance, "UNC\_ORT" for reflectance uncertainty, and "RFL\_ORT\_QL" for quicklook image.
- `<ext>` = file extension indicating file type: "nc" for netCDF, "tif" for GeoTIFF, "yaml" for YAML text file.

Example file names for one flight line are:

- `AV320230915t214314_001_L2A_OE_2404b400_RFL_ORT.nc`
- `AV320230915t214314_001_L2A_OE_2404b400_RFL_ORT_QL.tif`
- `AV320230915t214314_001_L2A_OE_2404b400 UNC_ORT.nc`
- `AV320230915t214314_001_L2A_OE_2404b400.yaml`

The surface reflectance (RFL) 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\_QL.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 = 284)	nm
fwhm	Full width at half maximum for band (n = 284)	nm
<b>RFL_ORT only</b>		
reflectance	Surface hemispherical directional reflectance factor in 284 bands covering wavelengths between 390 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 main objective of the AVIRIS project is to identify, measure, and monitor constituents of the Earth's surface and atmosphere based on molecular absorption and particle scattering signatures. Research with AVIRIS data is predominantly focused on understanding processes related to the global environment and climate change.

The Airborne Visible/Infrared Imaging Spectrometer 3 (AVIRIS-3) is the third of the NASA AVIRIS spectrometer series and was developed in parallel with the Compact Wide-swath Imaging Spectrometer II (CWIS-II) for the University of Zurich, Switzerland. The core spectrometer of AVIRIS-3 is a copy of the imaging spectrometer used by the Earth Surface Mineral Dust Source Investigation (EMIT) that has been deployed on the International Space Station (ISS). AVIRIS-Classic and AVIRIS-Next Generation are the two previously developed instruments (Green et al., 1998).

AVIRIS-3 provides state-of-the-art imaging spectroscopy measurements for NASA science and application through the next decade and beyond. It collects data that can be used for characterization of the Earth's surface and atmosphere from geometrically coherent spectroradiometric measurements. This data can be applied to studies in the fields of oceanography, environmental science, snow hydrology, geology, volcanology, soil and land management, atmospheric and aerosol studies, agriculture, and limnology. Applications under development include the assessment and monitoring of environmental hazards such as toxic waste, oil spills, and land/air/water pollution. With proper calibration and correction for atmospheric effects, the measurements can be converted to ground reflectance data which can then be used for quantitative characterization of surface features.

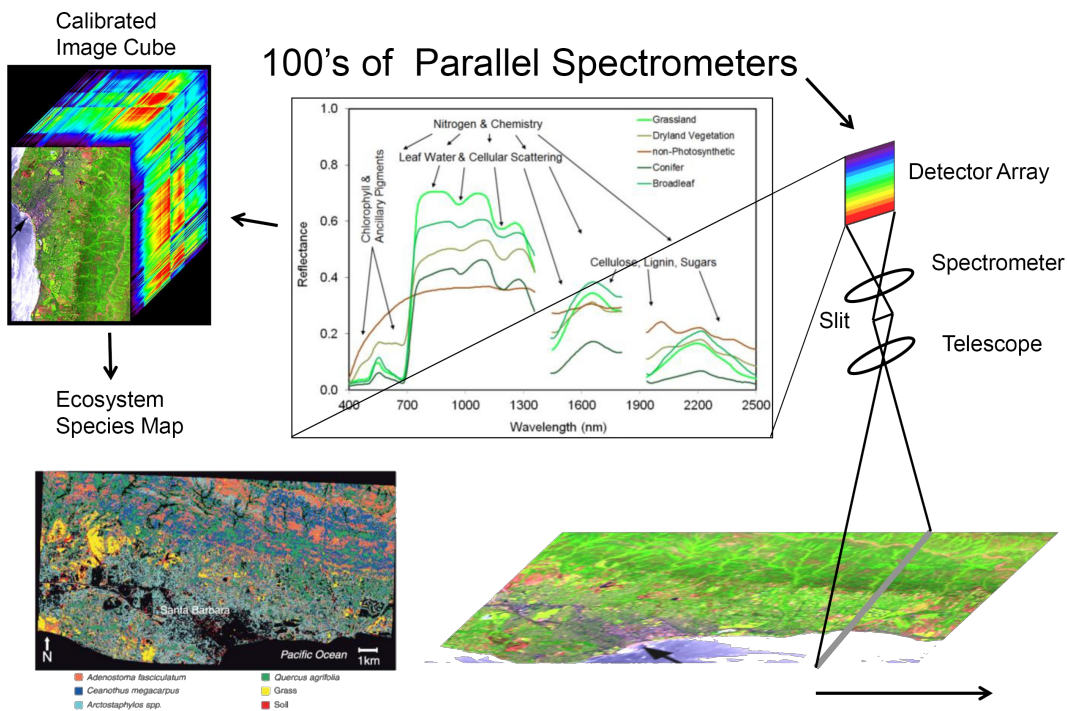


Figure 2. Overview of AVIRIS applications. Source: <https://avirisng.jpl.nasa.gov/aviris-ng.html>

## 4. Quality Assessment

The AVIRIS-3 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

The Airborne Visible-Infrared Imaging Spectrometer 3 (AVIRIS-3) was developed to provide state-of-the-art imaging spectroscopy measurements for NASA science and application through the next decade and beyond (Green et al., 2022). It is deployed on airborne platforms including NASA's B-200, Gulfstream III, Gulfstream V and potentially other aircraft. The sensor is a copy of an optically fast, F/1.8 Dyson imaging spectrometer used by the Earth Surface Mineral Dust Source Investigation (EMIT) instrument that has been deployed in orbit on the International Space Station (ISS).

AVIRIS-3 measures surface and atmospheric radiances in the wavelength range from 390 nm to 2500 nm with 7.4-nm sampling. Spectra are measured as images with 1234 cross-track elements and spatial sampling from 0.3 m to 10.0 m, depending on sensor-to-surface distance. It is a cryogenic instrument with advanced system control and real-time onboard spectroscopic data processing algorithms evolved from AVIRIS-NG. The radiometric range is from 0 to max terrestrial Lambertian radiance with higher signal-to-noise ratio performance than AVIRIS-Classic or AVIRIS-Next Generation. The spatial field-of-view is 39.5 degrees with 0.56 milliradian sampling (Green et al., 2022).

This Level 2A collection contains surface reflectance data for 284 bands in orthorectified format. L2A reflectances were derived from the associated [L1B radiance data](#). 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, fully described in the EMIT Level 2A ATBD (Thompson et al., 2020).

The OE algorithm produces two maps for each pixel; surface reflectance and reflectance uncertainty. The reflectance uncertainty map (UNC\_ORT) was derived from the diagonal elements of the posterior covariance matrix, square-rooted, to provide a spectrum of uncertainty about the reflectance estimate in standard deviations units. Together, these two products define the posterior probability of the surface reflectance given the at-sensor radiance measurement, captured as a multivariate normal distribution. Uncertainty-aware downstream analysis of the reflectance map can leverage both products, using the reflectance uncertainty as error bars over the reflectance estimate.

Pixel locations are provided in projected UTM coordinates. Nodata values are set to -9999.

## 6. Data Access

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

[AVIRIS-3 L2A Orthorectified Surface Reflectance, Facility Instrument Collection](#)

Contact for Data Center Access Information:

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

## 7. References

Chapman, J.W., D.R. Thompson, M.C. Helmlinger, B.D. Bue, R.O. Green, M.L. Eastwood, S. Geier, W. Olson-Duvall, and S.R. Lundeen. 2019. Spectral and radiometric calibration of the Next Generation Airborne Visible Infrared Spectrometer (AVIRIS-NG). *Remote Sensing* 11:2129.

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