Search ORNL DAAC 　　　　　　　 🔍 Search

MASTER: Airborne Science, Hawaii-Pacific Ocean-western US, Fall, 2001, V2

Get Data

Documentation Revision Date: 2023-02-23

Dataset Version: 2

Summary

This dataset includes Level 1B (L1B) and Level 2 (L2) data products from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The spectral data were collected during 19 flights aboard a NASA ER-2 aircraft over Hawaii, eastern Pacific Ocean, and western U.S. from 2001-10-14 to 2001-11-14. Data products include L1B georeferenced multispectral imagery of calibrated radiance in 50 bands covering wavelengths of 0.460 to 12.879 micrometers at approximately 50-meter spatial resolution. Derived L2 data products are emissivity in 5 bands in thermal infrared range (8.58 to 12.13 micrometers) and land surface temperature. The L1B file format is HDF-4, and L2 products are provided in ENVI and KMZ formats. In addition, the dataset includes the flight path, spectral band information, instrument configuration, ancillary notes, and summary information for each flight, and browse images derived from each L1B data file.

The MASTER instrument is a modified Daedalus Wildfire scanning spectrometer that flies on a variety of multi-altitude research aircraft and provides spectral information similar to that provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), which are aboard two NASA Earth Observing System satellites: Terra and Aqua. MASTER provides data in 50 channels spanning visible to thermal infrared wavelengths (0.4 – 13 μm). Its data have been used to study geological patterns, land covers, ecological disturbances, and other phenomena that affect Earth surface properties.

This dataset includes a total of 774 data files: 219 files in Hierarchical Data Format (HDF-4; *.hdf) format, 148 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 37 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 37 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 76 text (*.txt) files, 19 archives of text files that are zipped (*.zip), 19 flight maps as GIF (*.gif) images, and 219 browse images in JPEG (*.jpg) format.
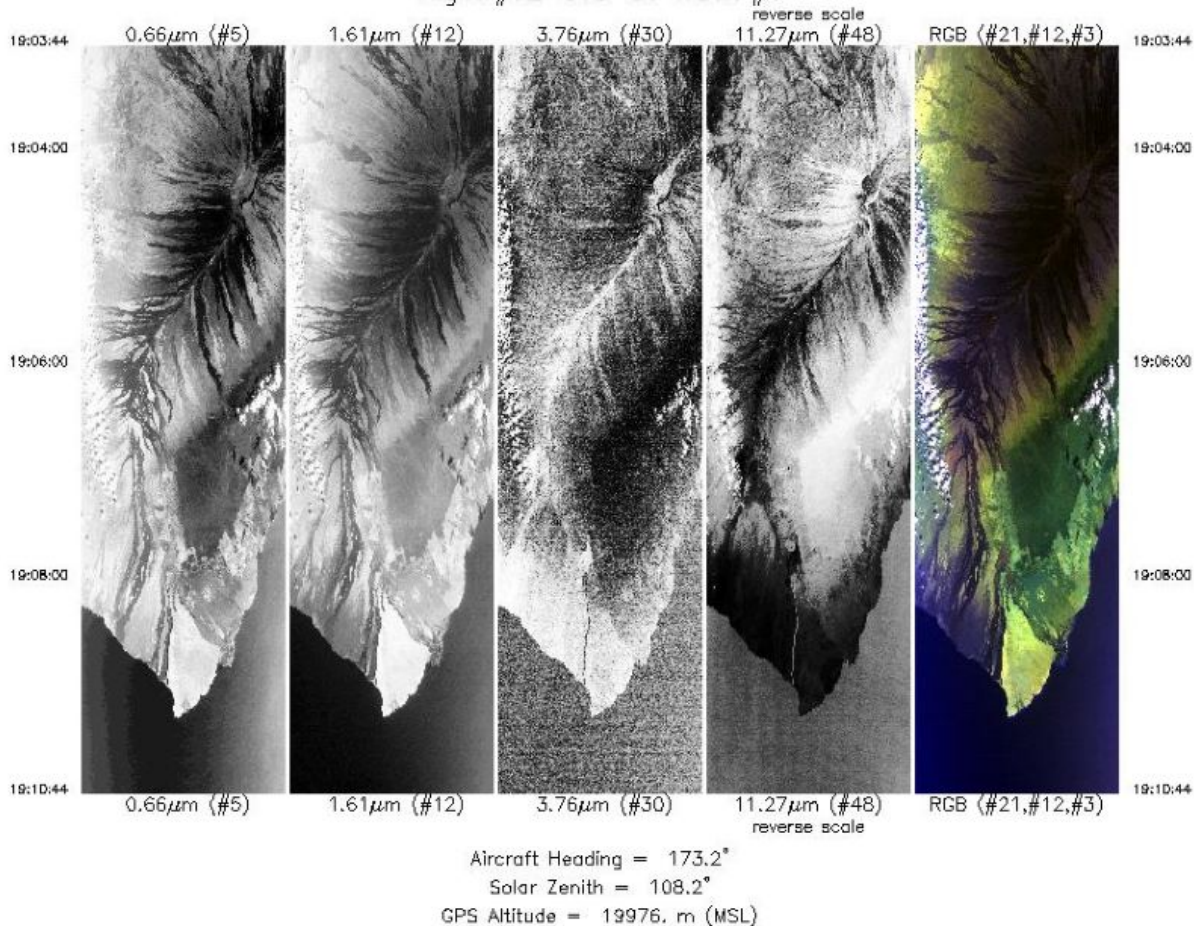
Figure 1. Single-band images and a RGB composite image from flight track 1 acquired on 19 October 2001 over southern portion of Hawaii's Big Island. Source: MASTERL1B_0290500_01_20011019_1903_1910_V01.jpg

Citation

Hook, S.J., J.S. Myers, K.J. Thome, M. Fitzgerald, A.B. Kahle, Airborne Sensor Facility NASA Ames Research Center, V.J. Realmuto, M. Goodman, S.L. Ustin, and G.P. Asner. 2022. MASTER: Airborne Science, Hawaii-Pacific Ocean-western US, Fall, 2001, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2142

Table of Contents

1. Dataset Overview

This dataset includes Level 1B (L1B) and Level 2 (L2) data products from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The spectral data were collected during 19 flights aboard a NASA ER-2 aircraft over Hawaii, eastern Pacific Ocean, and western U.S. from 2001-10-14 to 2001-11-14. Data products include L1B georeferenced multispectral imagery of calibrated radiance in 50 bands covering wavelengths of 0.460 to 12.879 micrometers at approximately 50-meter spatial resolution. Derived L2 data products are emissivity in 5 bands in thermal infrared range (8.58 to 12.13 micrometers) and land surface temperature. The L1B file format is HDF-4, and L2 products are provided in ENVI and KMZ formats. In addition, the dataset includes the flight path, spectral band information, instrument configuration, ancillary notes, and summary information for each flight, and browse images derived from each L1B data file.

The MASTER instrument is a modified Daedalus Wildfire scanning spectrometer that flies on a variety of multi-altitude research aircraft and provides spectral information similar to that provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), which are aboard two NASA Earth Observing System satellites: Terra and Aqua. MASTER provides data in 50 channels spanning visible to thermal infrared wavelengths (0.4 – 13 µm). Its data have been used to study geological patterns, land covers, ecological disturbances, and other phenomena that affect Earth surface properties.

Project: MODIS/ASTER Airborne Simulator

The MODIS/ASTER Airborne Simulator (MASTER) is a scanning spectrometer which flies on a variety of multi-altitude research aircraft and provides data similar to the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). MASTER first flew in 1998 and has ongoing deployments as a Facility Instrument in the NASA Airborne Science Program (ASP). MASTER is a joint project involving the Airborne Sensor Facility (ASF) at the Ames Research Center, the Jet Propulsion Laboratory (JPL), and the Earth Resources Observation and Science Center (EROS).

Related Publications

Hook, S.J. Myers, J.J., Thome, K.J., Fitzgerald, M. and A.B. Kahle. 2001. The MODIS/ASTER airborne simulator (MASTER) - a new instrument for earth science studies. Remote Sensing of Environment 76:93–102. https://doi.org/10.1016/S0034-4257(00)00195-4

Related Datasets

Additional MASTER datasets are available on the ORNL DAAC MASTER project page.

Acknowledgments

The MASTER instrument is maintained and operated by the Airborne Sensor Facility (ASF) at NASA Ames Research Center in Mountain View, California, under the oversight of the EOS Project Science Office at NASA Goddard. Data processing was conducted at NASA Ames Research Center and the Jet Propulsion Laboratory at the California Institute of Technology in Pasadena, California.

2. Data Characteristics

Spatial Coverage: Portions of Hawaii California, Nevada, Arizona, Utah, and eastern Pacific Ocean

Spatial Resolution: 50 m

Temporal Coverage: 2001-10-14 to 2001-11-14

Temporal Resolution: One-time estimate

Study Area: All latitudes and longitudes given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Hawaii, western U.S., Pacific Ocean	-166.704	-106.875	40.980	18.711

Data File Information

This dataset includes a total of 774 data files: 219 files in Hierarchical Data Format (HDF-4; *.hdf) format, 148 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 37 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 37 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 76 text (*.txt) files, 19 archives of text files that are zipped (*.zip), 19 flight maps as GIF (*.gif) images, and 219 browse images in JPEG (*.jpg) format.

There are different numbers of each type of file, which corresponds to the number of "flights" and "flight tracks". A "flight" is flown on a single day, and a "flight track" typically refers to a segment of a given flight. The number of flight tracks varies among flights (Table 2).

- There are 19 flights with 219 flight tracks (Table 2).
- For each of 219 flight tracks, there is one L1B data file in HDF format, one file in KMZ format, and one auxiliary browse image (*.jpg).
- L2 data are included for 37 of the 219 flight tracks. For each track, there is one L2 data file in KMZ format and five L2 data files in ZIP format.
  - Four of the ZIP files contain L2 ENVI data for emissivity, land surface temperature, geographic coordinates, and quality assurance status. Each ZIP includes a binary data file (*.dat) and its header file (*.hdr).
  - One ZIP file contains three L2 PNG files: RGB composite, single-band emissivity, and land surface temperature.
- For each flight, there is a collection of auxiliary files providing information about the flight and instrument configuration.

The primary data files are named MASTERL**AA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_**V0**J-X**.**ext** (e.g., MASTERL1B_0290200_01_20011014_1622_1633_V01.hdf).

The flight track-level browse images are named MASTERL**AA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_**V0**J**.jpg (e.g., MASTERL1B_0290200_01_20011014_1622_1633_V01.jpg).

The flight-level auxiliary files are named MASTER**_BBBBBBBB_YYYYMMDD_X**.**ext** (e.g., MASTER_0290200_20011014_config.txt).

Elements of file names are described as:

AA = "1B" or "2", indicating L1B or L2 data level,
BBBBBBBB = flight number (Table 2),
CC = flight track (Table 2),
YYYYMMDD = date of sampling,
EEFF = starting time at EE hour and FF minute,
GGHH = ending time at GG hour and HH minute,
J = version number for file,
X = the file content (see Table 1), and
ext = "hdf", "kmz", "gif", "jpg", "txt", or "zip", indicating the file extension.

Table 1. File names and descriptions.

File Name	Level	File Type	Total Files	Description
Primary Data Files				
MASTERL1B_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_*V0J.hdf	L1B	HDF-4	219	Multispectral radiance in 50 bands, pixel coordinates, sensor configuration, aircraft platform data, analysis parameters. The "CalibratedData" variable provides estimates of radiance in units of W m^{-2} sr^{-1} per micron.

File Name	Level	File Type	Total Files	Description
MASTERL1B_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*V0J-RGB.kmz	L1B	KMZ	37	RGB composite browse image (in KMZ format) derived from corresponding bands of RGB wavelengths of L1B data.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0J-emissivity_tes.zip	L2	ENVI	37	Map of atmospheric corrected emissivity; Temperature and Emissivity Separation (TES) corrected data in 5 bands (wavelengths: 8.58, 9.02, 10.62, 11.32, and 12.13 μm).
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0J-images.zip	L2	PNG	37	Three non-georeferenced images depicting (a) RGB composite using selected bands, (b) emissivity from a single band, and (c) land surface temperature.
MASTERL2_B*BBBBBBBB_CC_ YYYYmmDD_EEFF_GGHH*_V0J-location.zip	L2	ENVI	37	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0J-LST.kmz	L2	KMZ	37	Map of land surface temperature in degrees Kelvin.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0J-QAmap.zip	L2	ENVI	37	QA status for each pixel from TES algorithm, where 1 = divergence and 0 = convergence.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0J-surface_temp.zip	L2	ENVI	37	Map of land surface temperature (TES LST) in degrees Kelvin.
Auxiliary Files				
MASTERLAA_*BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0J.jpg	L1B	JPEG	219	Browse figures; one image per flight track; multiple tracks per flight.
MASTER_*BBBBBBBB_YYYYMMDD*_ancillary.txt	-	Text	19	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_*BBBBBBBB_YYYYMMDD*_config.txt	-	Text	19	Instrument configuration information for flight.
MASTER_*BBBBBBBB_YYYYMMDD*_flightpath.gif	-	GIF	19	Map showing flight paths.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_band_info.txt	-	Text	19	Spectral band information for flight.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_response_table.zip	-	Text	19	Spectral response tables by band (ZIP archive of 50 text files).
MASTER_*BBBBBBBB_YYYYMMDD*_summary.txt	-	Text	19	Time and coordinates for start and end of flight tracks along with the number of scan lines, solar and instrument angles, and aircraft altitude. FTLT = flight track number.

Data File Details

The HDF and ENVI files contain swath trajectory data using longitude and latitude coordinates. The spatial resolution is approximately 50 m and is a function of aircraft altitude.

Table 2. Number of flight tracks per file data level for each MASTER flight during this 2001 deployment over Hawaii (HI), California (CA), Nevada (NV), Arizona (AZ), and Utah (UT)

Date	Flight Number	Locations	Flight Tracks	
			Data Level L1B	L2
2001-10-14	0290200	Southern Sierra, CA	6	3
2001-10-15	0290300	CA, Coast	13	4
2001-10-17	0290400	Big Island, HI	13	0
2001-10-19	0290500	S. Big Island, HI	18	2
2001-10-20	0290600	Big Island, HI	15	0
2001-10-23	0290700	Big Island, HI	6	3
2001-10-24	0290800	Big Island, HI	17	0
2001-10-26	0290900	Fr. Frigate Shoals, HI	3	0
2001-10-26	0291000	Kahoolawe, HI	9	0

2001-10-29	0291100	Lanai Offshore, HI	18	0
2001-10-31	0291200	Lanai Offshore, HI	17	3
2001-11-01	0291300	Maui, HI	7	3
2001-11-02	0291400	Maui, HI	10	0
2001-11-05	0291500	Maui, HI	7	0
2001-11-05	0291600	Lanai and Maui, HI	10	0
2001-11-06	0291700	Molokai, HI	9	0
2001-11-07	0291800	Hawaii	15	3
2001-11-09	0291900	CA, NV, UT, AZ	12	10
2001-11-14	0292000	Southern CA	14	6
		Total	219	37

User Note: Data for flights 0290800 and 0290900 are not georeferenced. Although the HDFs include the aircraft and pixel coordinate variables, those variables are filled with missing data. Missing latitude and longitude values are indicated by the values of 0, -999 (latitude), or -639 (longitude).

3. Application and Derivation

The primary objective of MASTER is to: (a) collect ASTER-like and MODIS-like land datasets to support the validation of the ASTER and MODIS geophysical retrieval algorithms; (b) collect these datasets at a higher resolution than the spaceborne datasets to permit scaling studies and comparisons with in situ measurements; and (c) under fly the EOS-AM1 ASTER and MODIS sensors to provide an additional radiometric calibration to assist with in-flight instrument performance characterization. Calibration is particularly important for ASTER where on-board calibration is dependent on a single black body in the TIR and only partial aperture illumination in the VNIR.

A secondary objective of MASTER is to: (a) provide both a backup instrument and backup modules for the current MODIS Airborne simulator, which is committed to a program of atmospheric and oceanic measurements; and (b) provide a wider spectral and dynamic range alternative to the use of the Thematic Mapper (TM) airborne simulator and Thermal Infrared Multispectral Scanner (TIMS) airborne scanners (JPL, 2021b).

MASTER imagery has been used for mapping wildfires and their impacts (Veraverbeke et al., 2011), land cover (Li and Moon, 2004), coral reefs (Capolsini et al., 2003), and urban heat islands (Zhao and Wentz, 2016).

4. Quality Assessment

The MASTER instrument channels are calibrated spectrally and radiometrically in the laboratory preflight and postflight. The mid-infrared and thermal infrared channels (26–50) are also radiometrically calibrated in-flight by viewing an internal hot and cold blackbody with each scanline (Hook et al., 2001). Three calibration and validation experiments were conducted in 1998–2001 (Hook et al., 2001; JPL, 2021a). Spectral response information for this deployment is included in the files named MASTER_*BBBBBBBB_YYYYMMDD*_spectral_response_table.zip.

5. Data Acquisition, Materials, and Methods

The MASTER instrument was developed by the NASA Ames Research Center in conjunction with the Jet Propulsion Laboratory. The instrument consists of three key components: the scanning spectrometer, the digitizer, and the storage system. The scanning unit was built by Sensys Technology (formerly Daedalus Enterprises) and the digitizer was a collaborative effort between Berkeley Camera Engineering and the Ames Airborne Sensor Facility (ASF, 2021). The data storage system and overall system integration were also provided by the ASF.

The MASTER instrument is similar to the MODIS Airborne Simulator (MAS) developed by the MODIS project (King et al., 1996). However, it has two key differences. First, MASTER supports a variety of scan speeds allowing it to acquire contiguous imagery from a variety of altitudes with different pixel sizes. Second, the channel positions are configured to closely match those of ASTER and MODIS. A detailed description of the instrument and optical system are provided by Hook et al. (2001) and King et al. (1996), respectively.

For this deployment, the MASTER instrument was flown on NASA's ER-2 aircraft at altitudes of 18,885–20,035 m above sea level.

The L2 data are derived from the L1B files, and the primary L2 products are emissivity in five bands (wavelengths: 8.58, 9.02, 10.62, 11.32, and 12.13 μm) and land surface temperature (LST). Emissivity and LST were corrected using a Temperature and Emissivity Separation (TES) algorithm (Coll et al., 2001).
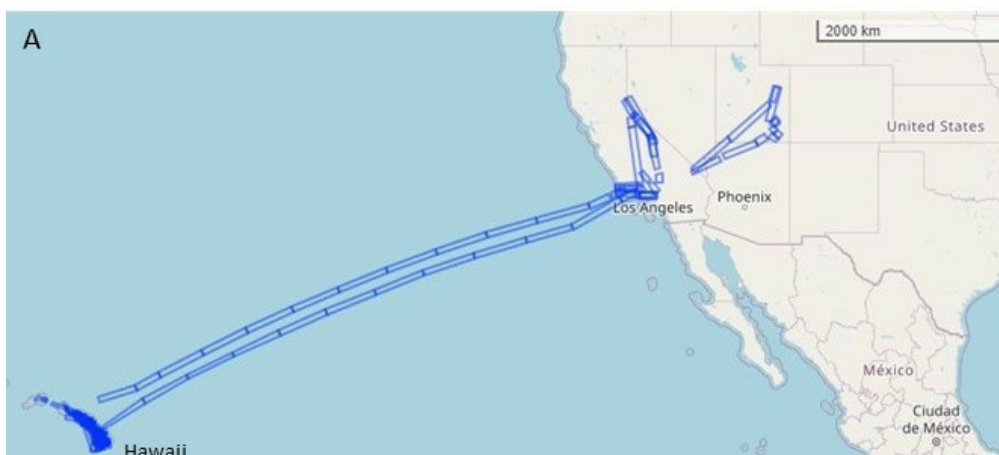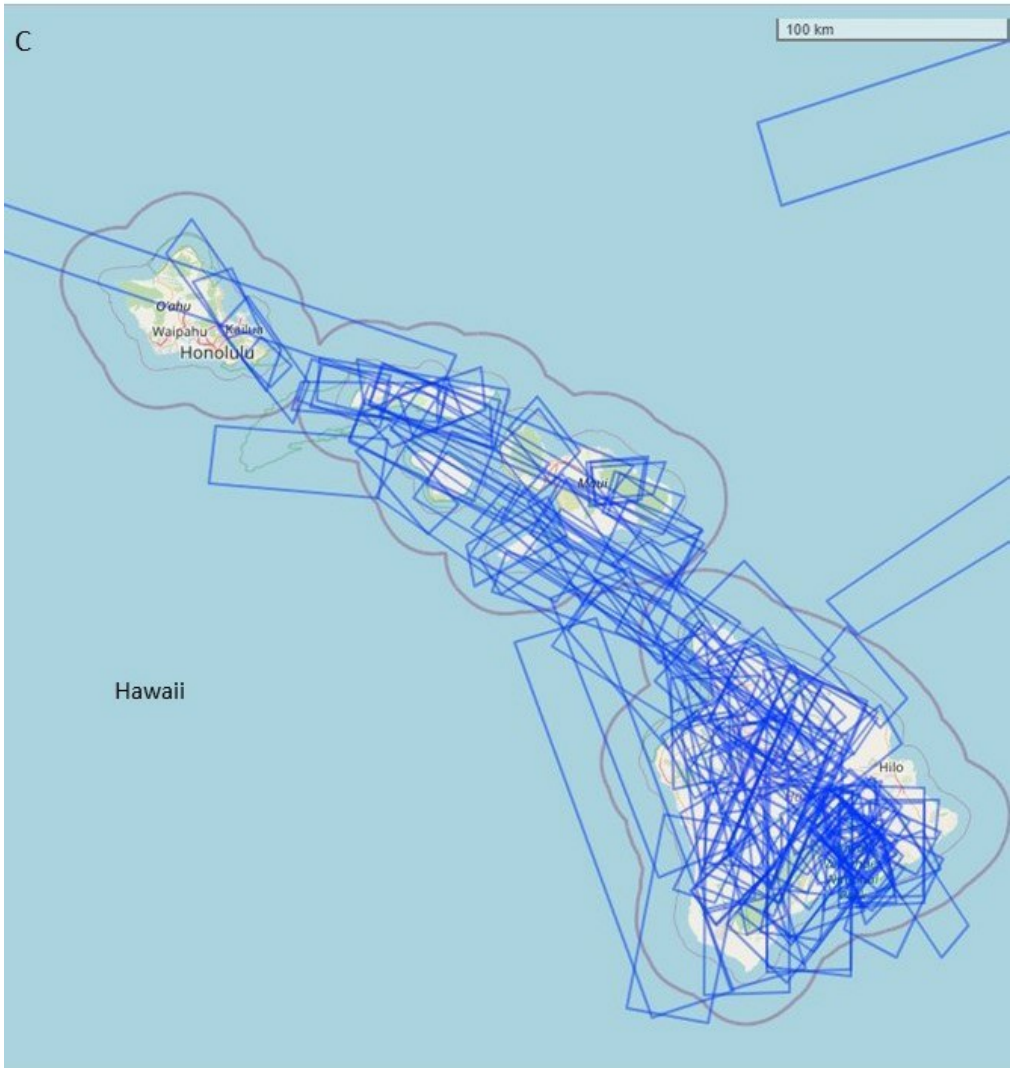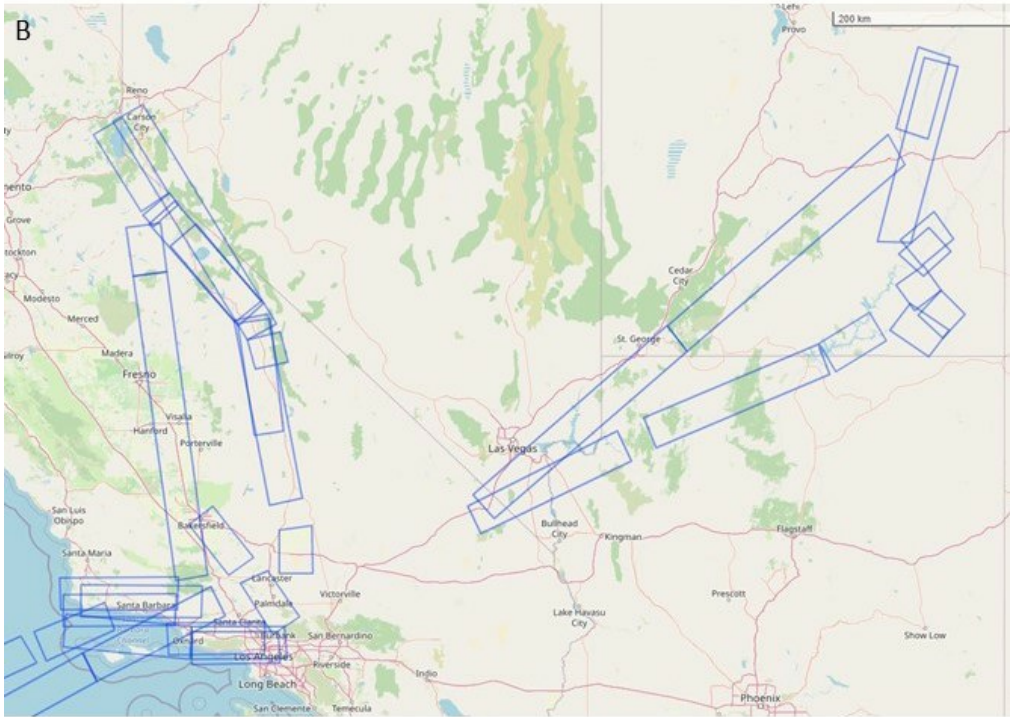
Figure 2. Flight tracks in this dataset represented as rectangular polygons. Map A shows all flight tracks. Maps B and C focus on the flight tracks in western US and Hawaii, respectively. Basemap: © OpenStreetMap contributors.
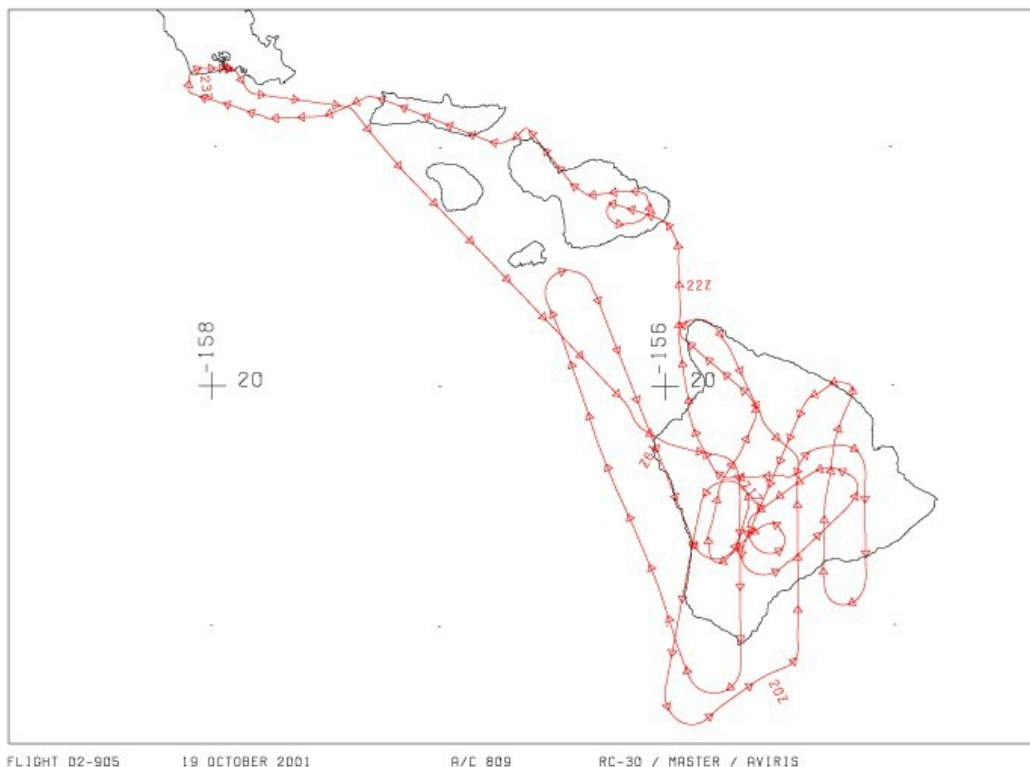
Figure 3. Flight path for Flight 0290500, flown on 19 October 2001. Flight 0290500 and 18 flight tracks occurred over the Big Island of Hawaii, U.S. Source: MASTER_0290500_20011019_flightpath.gif

6. Data Access

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

MASTER: Airborne Science, Hawaii-Pacific Ocean-western US, Fall, 2001, V2

Contact for Data Center Access Information:

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

7. References

ASF. 2021. Campaign summary information: HyspIRI / WDTS Airborne Campaign. Airborne Sensor Facility, Airborne Science Program, NASA Ames Research Center, Moffett Field, California. https://asapdata.arc.nasa.gov/sensors/master/data/deploy_html/hyspiri_home.html

Capolsini, P., S. Andréfouët, C. Rion, and C. Payri. 2003. A comparison of Landsat ETM+, SPOT HRV, Ikonos, ASTER, and airborne MASTER data for coral reef habitat mapping in South Pacific islands. Canadian J. Remote Sensing 29:187-200. https://doi.org/10.5589/m02-088

Coll, C., V. Caselles, E. Rubio, F. Sospedra, and E. Valor. 2001. Temperature and emissivity separation from calibrated data of the Digital Airborne Imaging Spectrometer. Remote Sensing of Environment 76:250-259. https://doi.org/10.1016/S0034-4257(00)00207-8

Hook, S.J. Myers, J.J., Thome, K.J., Fitzgerald, M., and A. B. Kahle. 2001. The MODIS/ASTER airborne simulator (MASTER) - a new instrument for earth science studies. Remote Sensing of Environment 76:93-102. https://doi.org/10.1016/S0034-4257(00)00195-4

JPL. 2021a. Calibration and Validation, MASTER: MODIS/ASTER Airborne Simulator. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA. https://masterprojects.jpl.nasa.gov/cal-val

JPL. 2021b. Science objectives, MASTER: MODIS/ASTER Airborne Simulator. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA. https://masterprojects.jpl.nasa.gov/objectives

King, M.D., W.P. Menzel, P.S. Grant, J.S. Myers, G.T. Arnold, S.E. Platnick, L.E. Gumley, S.C. Tsay, C.C. Moeller, M. Fitzgerald, K.S. Brown, and F.G. Osterwisch. 1996. Airborne scanning spectrometer for remote sensing of cloud, aerosol, water vapor and surface properties. J. Atmospheric and Oceanic Technology 13:777-794. https://doi.org/10.1175/1520-0426(1996)013<0777:ASSFRS>2.0.CO;2

Li, P., and W.M. Moon. 2004. Land cover classification using MODIS-ASTER airborne simulator (MASTER) data and NDVI: A case study of the Kochang area, Korea. Canadian J. Remote Sensing 30:123-126. https://doi.org/10.5589/m03-061

Veraverbeke, S., S. Harris, and S. Hook. 2011. Evaluating spectral indices for burned area discrimination using MODIS/ASTER (MASTER) airborne simulator data. Remote Sensing of Environment 115:2702-2709. https://doi.org/10.1016/j.rse.2011.06.010

Zhao, Q., and E.A. Wentz. 2016. A MODIS/ASTER Airborne Simulator (MASTER) imagery for urban heat island research. Data 1:7. https://doi.org/10.3390/data1010007

8. Dataset Revisions

Version	Release Date	Revision Notes

2.0	2023-02-23	Summary and ancillary files were replaced with corrected versions
1.0	2022-10-05	Original publication

OAK RIDGE
National Laboratory

 Home

About Us
Mission
Data Use and Citation Policy
User Working Group
Partners

Get Data
Science Themes
NASA Projects
All Datasets

Submit Data
Submit Data Form
Data Scope and Acceptance
Data Authorship Policy
Data Publication Timeline
Detailed Submission Guidelines

Tools
MODIS
THREDDS
SDAT
Daymet
Airborne Data Visualizer
Soil Moisture Visualizer
Land - Water Checker

Resources
Learning
Data Management
News
Earthdata Forum

Contact Us