MASTER: Airborne Science, Western US, April, 2004

Get Data

Documentation Revision Date: 2023-04-14

Dataset Version: 1

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 four flights aboard a NASA ER-2 aircraft over western U.S. and Pacific Ocean from 2004-04-01 to 2004-04-13. This deployment was coordinated by NASA's Dryden Flight Research Center (DRFC), renamed Armstrong Flight Research Center in 2014, located in Edwards, California. 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 flight paths, 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 306 data files: 48 files in Hierarchical Data Format (HDF-4; *.hdf) format, 124 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 31 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 31 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 16 text (*.txt) files, 4 archives of text files that are zipped (*.zip), 4 flight maps as GIF (*.gif) images, and 48 browse images in JPEG (*.jpg) format.

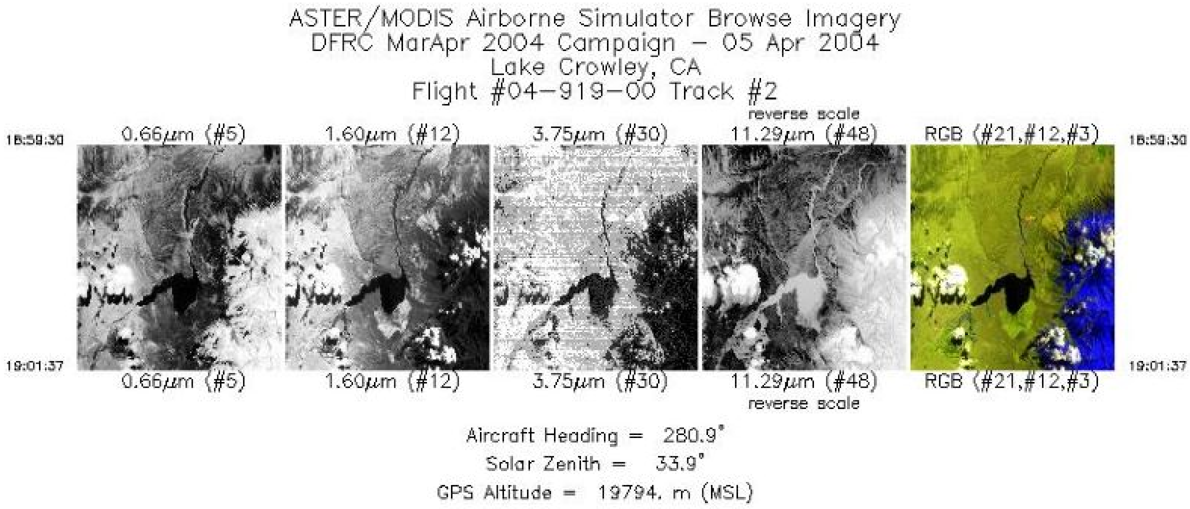

Figure 1. Single-band images and a RGB composite image from flight track 2 as acquired on 05 April 2004 over Crowley Lake southeast of Lee Vining, California, U.S. Source: MASTERL1B_0491900_02_20040405_1859_1901_V01.jpg

Citation

Hook, S.J., J.S. Myers, K.J. Thome, M. Fitzgerald, A.B. Kahle, Airborne Sensor Facility NASA Ames Research Center, T.H. Painter, J. Dozier, and C.C. Moeller. 2022. MASTER: Airborne Science, Western US, April, 2004. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2043

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 four flights aboard a NASA ER-2 aircraft over western U.S. and Pacific Ocean from 2004-04-01 to 2004-04-13. This deployment was coordinated by NASA’s Dryden Flight Research Center (DRFC), renamed Armstrong Flight Research Center in 2014, located in Edwards, California. 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 flight paths, 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 Publication

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 California, Nevada, Utah, Arizona, Colorado and eastern Pacific Ocean

Spatial Resolution: 50 m

Temporal Coverage: 2004-04-01 to 2004-04-13

Temporal Resolution: One-time estimate

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
western U.S. and Pacific Ocean	-129.375	-101.250	45.089	27.059

Data File Information

This dataset includes a total of 306 data files: 48 files in Hierarchical Data Format (HDF-4; *.hdf) format, 124 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 31 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 31 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 16 text (*.txt) files, 4 archives of text files that are zipped (*.zip), 4 flight maps as GIF (*.gif) images, and 48 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 four flights, which include 48 flight tracks (Table 2).
- For each of 48 flight tracks, there is one L1B data file in HDF format and one auxiliary browse image (*.jpg).
- L2 data are included for 31 of the 48 flight tracks. For each track, there is one KMZ file derived from L1B data 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: RBG 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_0491800_01_20040401_0158_0209_V01.hdf).

The flight track-level browse images are named MASTERL **AA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH**_V0**J**.jpg (e.g., MASTERL1B_0491800_01_20040401_0158_0209_V01.jpg).

The deployment-level auxiliary files are named MASTER_**BBBBBBBB_YYYYMMDD_X.ext** (e.g., MASTER_0491800_20040401_config.txt).

- 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	48	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.
MASTERL1B_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*V0J-RGB.kmz	L1B	KMZ	31	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	31	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	31	Three non-georeferenced images depicting (a) RGB composite using selected bands, (b) emissivity from a single band, and (c) land surface temperature.
MASTERL2_B*BBBBBBB_CC_ YYYYmmDD_EEFF_GGHH*_V0J-location.zip	L2	ENVI	31	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0J-QAmap.zip	L2	ENVI	31	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	31	Map of land surface temperature (TES LST) in degrees Kelvin.
Auxiliary files				
MASTERLAA_*BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0J.jpg	L1B	JPEG	48	Browse figures; one per flight track, multiple tracks per flight.
MASTER_*BBBBBBBB_YYYYMMDD*_ancillary.txt	-	Text	4	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_*BBBBBBBB_YYYYMMDD*_config.txt	-	Text	4	Instrument configuration information for flight.
MASTER_*BBBBBBBB_YYYYMMDD*_flightpath.gif	-	GIF	4	Map showing flight paths.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_band_info.txt	-	Text	4	Spectral band information.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_response_table.zip	-	Text	4	Spectral response tables by band (ZIP archive of 50 text files).
MASTER_*BBBBBBBB_YYYYMMDD*_summary.txt	-	Text	4	Time and coordinates for start and end of flight tracks along with the number of scan lines, solar and instrument angles, aircraft altitude, and additional information. FTLT = flight track number.

Data File Details

The HDF-4 and ENV files contain swath trajectory data using longitude, latitude coordinates. The spatial resolution is 50 m and is a function of aircraft altitude.

Table 2. Number of flight tracks for each MASTER flight during this 2004 deployment over California (CA) and other states in western US.

Date	Flight Number	Locations (USA)	Flight Tracks	
		Data Level	L1B	L2
2004-04-01	0491800	Sierra Nevada Mts, CA	10	8
2004-04-05	0491900	Owens Valley, CA	7	5

2004-04-09	0492000	Sierra Nevada Mts, CA	15	5
2004-04-13	0492100	Arizona / Colorado / Utah / Nevada	16	13
Total			48	31

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 covers (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 MASTER_BBBBBBBB_YYYYMMDD_spectral_response_table.zip files.

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). 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 19,170 - 20,010 m above sea level.

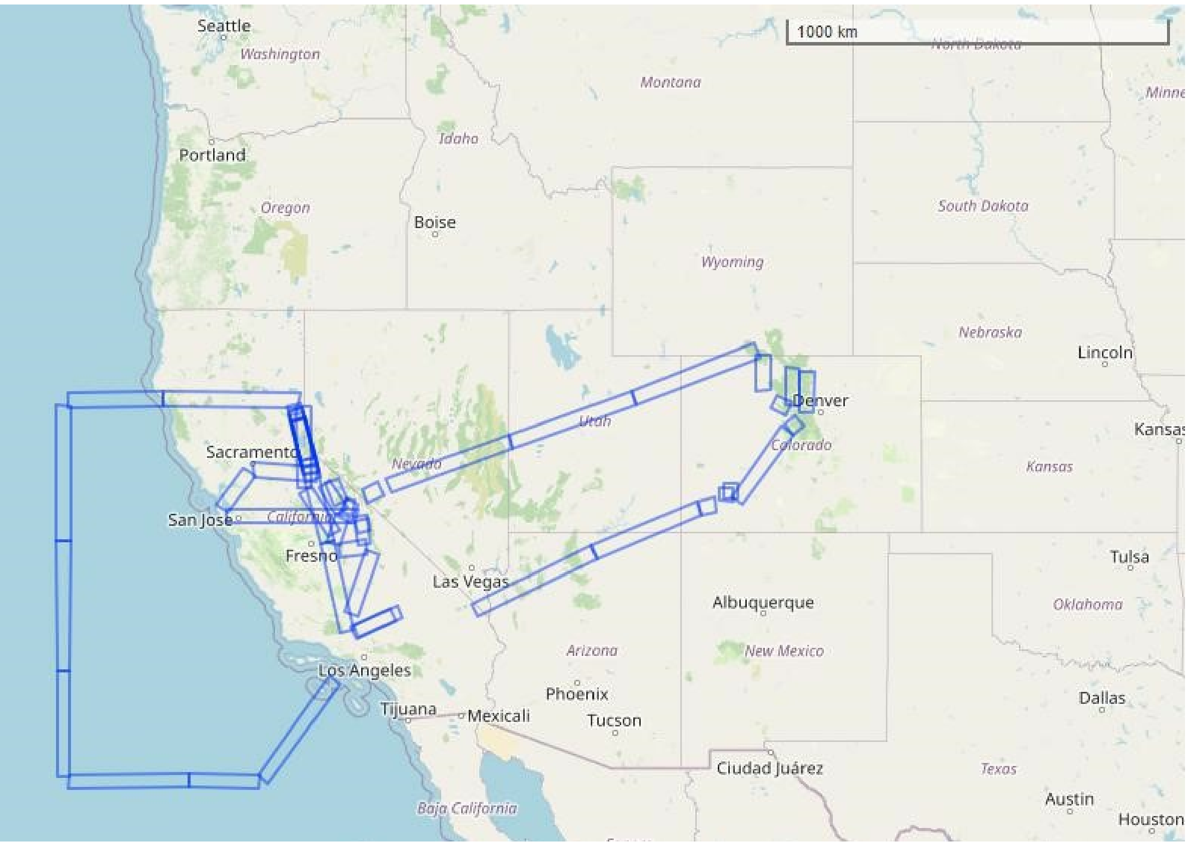

Figure 2. Flight tracks in this dataset represented as blue rectangular polygons. Basemap: © OpenStreetMap contributors.

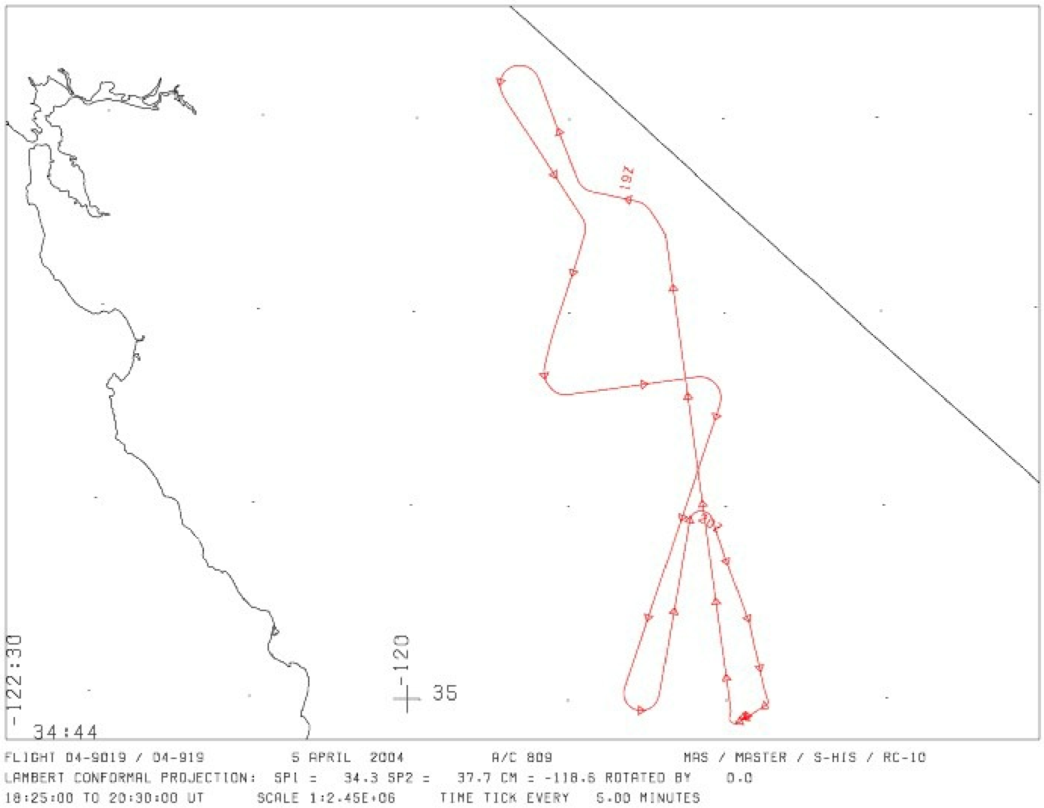

Figure 3. Typical flight path is shown for April 5, 2004 over California. Flight 0491900 and 7 flight tracks. Source: MASTER_0491900_20040405_flightpath.gif

6. Data Access

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

MASTER: Airborne Science, Western US, April, 2004

Contact for Data Center Access Information:

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

7. References

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