MASTER: Airborne Science, Southwest US, May, 2011

Get Data

Documentation Revision Date: 2023-04-13

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 five flights aboard a NASA ER-2 aircraft over southwestern U.S., from 2011-05-15 to 2011-05-23. 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 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.

This dataset includes a total of 402 data files: 52 files in Hierarchical Data Format (HDF-4; *.hdf) format, 144 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 88 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 36 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 20 text (*.txt) files, 5 archives of text files that are zipped (*.zip), 5 flight maps as GIF (*.gif) images, and 52 browse images in JPEG (*.jpg) format.

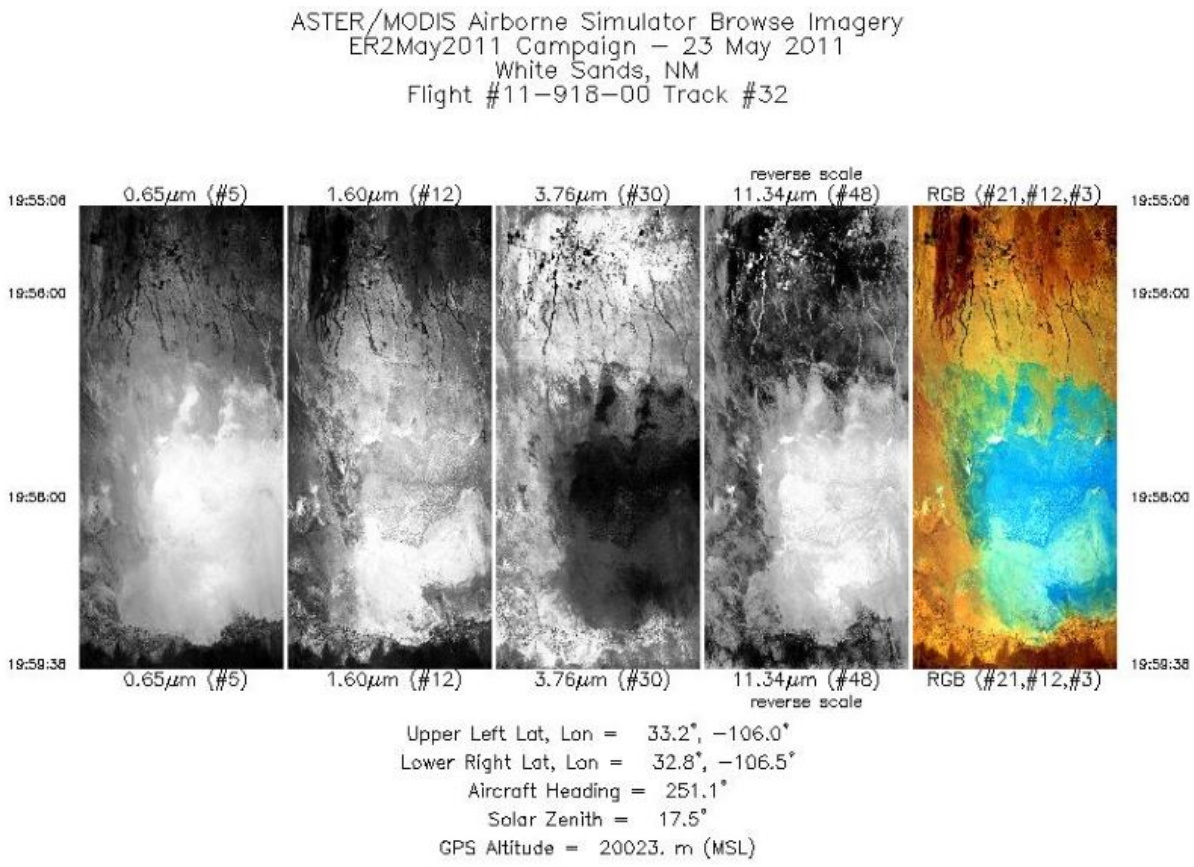

Figure 1. Single band images and an RGB composite image from flight track 32 acquired on 23 May 2011 over White Sands National Park, west of Alamogordo, New Mexico, U.S. Source: MASTERL1B_1191800_32_20110523_1955_1959_V01.jpg

Citation

Hook, S.J., J.S. Myers, K.J. Thome, M. Fitzgerald, A.B. Kahle, Airborne Sensor Facility NASA Ames Research Center, R.O. Green, T.H. Painter, R. Iacovazzi, R. Pollock, and S.L. Ustin. 2022. MASTER: Airborne Science, Southwest US, May, 2011. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1985

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1. Dataset Overview

This dataset includes Level 1B (L1B) and Level 2 (L2) data products from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The raw data were collected during five flights aboard a NASA ER-2 aircraft over southwestern U.S., from 2011-05-15 to 2011-05-23. 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 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.

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, Arizona, New Mexico, and Colorado, U.S.

Spatial Resolution: 20 to 50 m

Temporal Coverage: 2011-05-15 to 2011-05-23

Temporal Resolution: One-time estimate

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
southwestern U.S.	-120.235	-101.250	38.823	31.952

Data File Information

This dataset includes a total of 402 data files: 52 files in Hierarchical Data Format (HDF-4; *.hdf) format, 144 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 88 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 36 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 20 text (*.txt) files, 5 archives of text files that are zipped (*.zip), 5 flight maps as GIF (*.gif) images, and 52 browse images in JPEG (*.jpg) format (Table 1).

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 5 flights with 52 flight tracks (Table 2).
- For each of 52 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 36 of the 52 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_1191500_02_20110516_1827_1831_V01.hdf).

The flight track-level browse images are named MASTERL**AA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH**_V0**J**.jpg (e.g., MASTERL1B_1191500_02_20110516_1827_1831_V01.jpg).

The flight-level auxiliary files are named MASTER_**BBBBBBBB_YYYYMMDD_X**.**ext** (e.g., MASTER_1191500_20110516_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*_V0*J*.hdf	L1B	HDF-4	52	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*V0*J*-RGB.kmz	L1B	KMZ	52	RGB composite browse image (in KMZ format) derived from corresponding bands of RGB wavelengths of L1B data.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0*J*-emissivity_tes.zip	L2	ENVI	36	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*_V0*J*-images.zip	L2	PNG	36	Three non-georeferenced images depicting (a) RGB composite using selected bands, (b) emissivity from a single band, and (c) land surface temperature.
MASTERL2_*BBBBBBBB_CC_ YYYYmmDD_EEFF_GGHH*_V0*J*-location.zip	L2	ENVI	36	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0*J*-LST.kmz	L2	KMZ	36	Map of land surface temperature in degrees Kelvin.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0*J*-QAmap.zip	L2	ENVI	36	QA status for each pixel from TES algorithm, where 1 = divergence and 0 = convergence.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0*J*-surface_temp.zip	L2	ENVI	36	Map of land surface temperature (TES LST) in degrees Kelvin.
Auxiliary Files				
MASTERLAA_*BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*.jpg	L1B	JPEG	52	Browse figures; one image per flight track; multiple tracks per flight.
MASTER_*BBBBBBBB_YYYYMMDD*_ancillary.txt	-	Text	5	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_*BBBBBBBB_YYYYMMDD*_config.txt	-	Text	5	Instrument configuration information for flight.
MASTER_*BBBBBBBB_YYYYMMDD*_flightpath.gif	-	GIF	5	Map showing flight paths.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_band_info.txt	-	Text	5	Spectral band information for flight.

File Name	Level	File Type	Total Files	Description
MASTER_*BBBBBBBB*_*YYYYMMDD*_spectral_response_table.zip	-	Text	5	Spectral response tables by band (ZIP archive of 50 text files).
MASTER_*BBBBBBBB*_*YYYYMMDD*_summary.txt	-	Text	5	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 20 to 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 2011 deployment.

Date	Flight Number	Locations (U.S.)	Flight Tracks	
		Data Level	L1B	L2
2011-05-15	1191400	Salton Sea, California	3	
2011-05-16	1191500	Colorado / Arizona	4	3
2011-05-20	1191600	Central Valley, California	4	
2011-05-20	1191700	Central Valley, California	5	
2011-05-23	1191800	White Sands, New Mexico	36	33
		Total	52	36

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 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 campaign, the MASTER deployment was flown on NASA's ER-2 aircraft at altitudes of 7509 – 20,129 m above sea level. The study area included portions of California, Nevada, Arizona, New Mexico, and Colorado (Fig. 2). The purposes of these flights include collecting data for wildfire mapping, airborne science initiatives, and calibration of AVIRIS satellite sensor.

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 shows southwestern U.S. and northern Mexico. Basemap: © OpenStreetMap contributors.

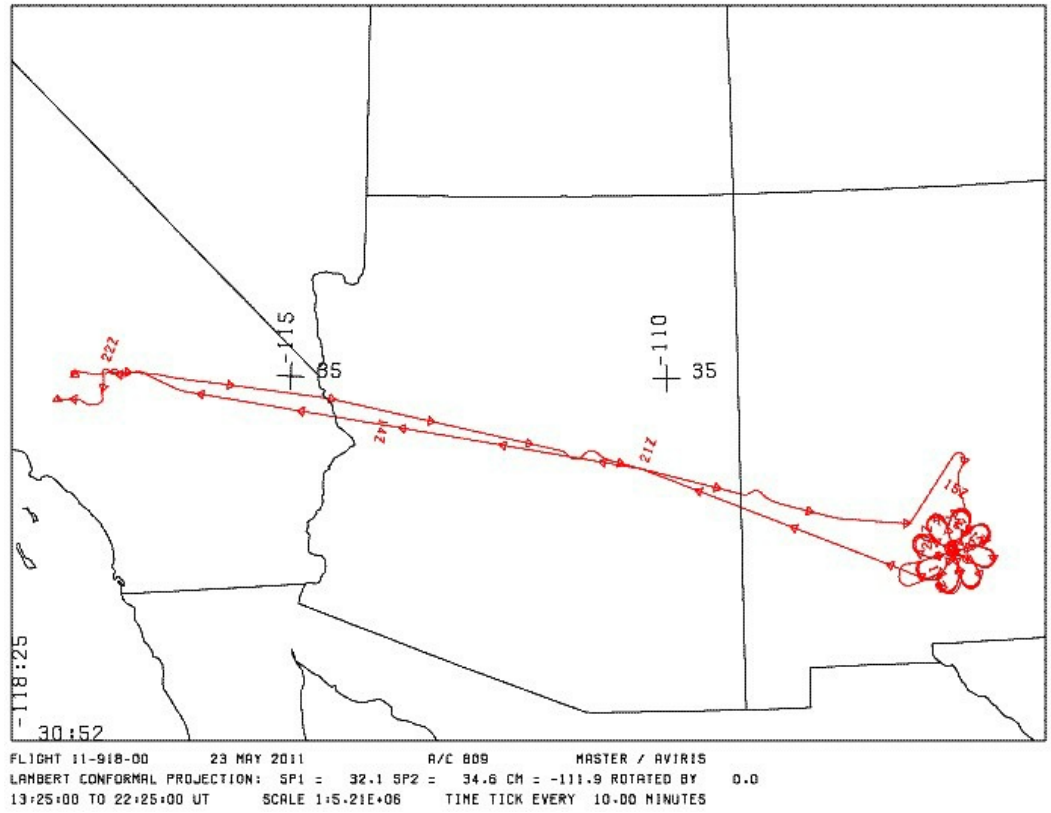

Figure 3. Flight path for Flight 1191800, flown on 23 May 2011. Flight 1191800 and 9 flight tracks occurred over White Sands, New Mexico, U.S. (flower pattern on right). The flight includes roundtrip transit from base in southern California. Source: MASTER_1191800_20110523_flightpath.gif

6. Data Access

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

MASTER: Airborne Science, Southwest US, May, 2011

Contact for Data Center Access Information:

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

7. References

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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

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