MASTER: Western Diversity Time Series Campaign, WDTS, California, USA, Fall 2020

Get Data

Documentation Revision Date: 2023-06-19

Dataset Version: 1.2

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 as part of the Western Diversity Time Series (WDTS, formerly HyspIRI) program during nine flights aboard a NASA ER-2 aircraft over selected areas of California, U.S, from 2020-09-17 to 2020-10-15. The WDTS program will observe California's ecosystems and provide critical information on natural disasters such as volcanoes, wildfires, and drought. MASTER products can identify vegetation type and health and provide a benchmark for the state of the ecosystems against which future changes can be assessed. 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 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 deployment, 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. The primary goal of this airborne campaign was to demonstrate important science and applications research that is uniquely enabled by the full suite of MASTER thermal infrared bands as well as the contiguous spectroscopic measurements of the AVIRIS (also flown in similar campaigns), or combinations of measurements from both instruments.

This dataset includes a total of 732 data files: 90 files in Hierarchical Data Format (HDF-4; *.hdf) format, 332 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 83 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 83 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 36 text (*.txt) files, 9 archives of text files that are zipped (*.zip), 9 flight maps as GIF (*.gif) images, and 90 browse images in JPEG (*.jpg) format.

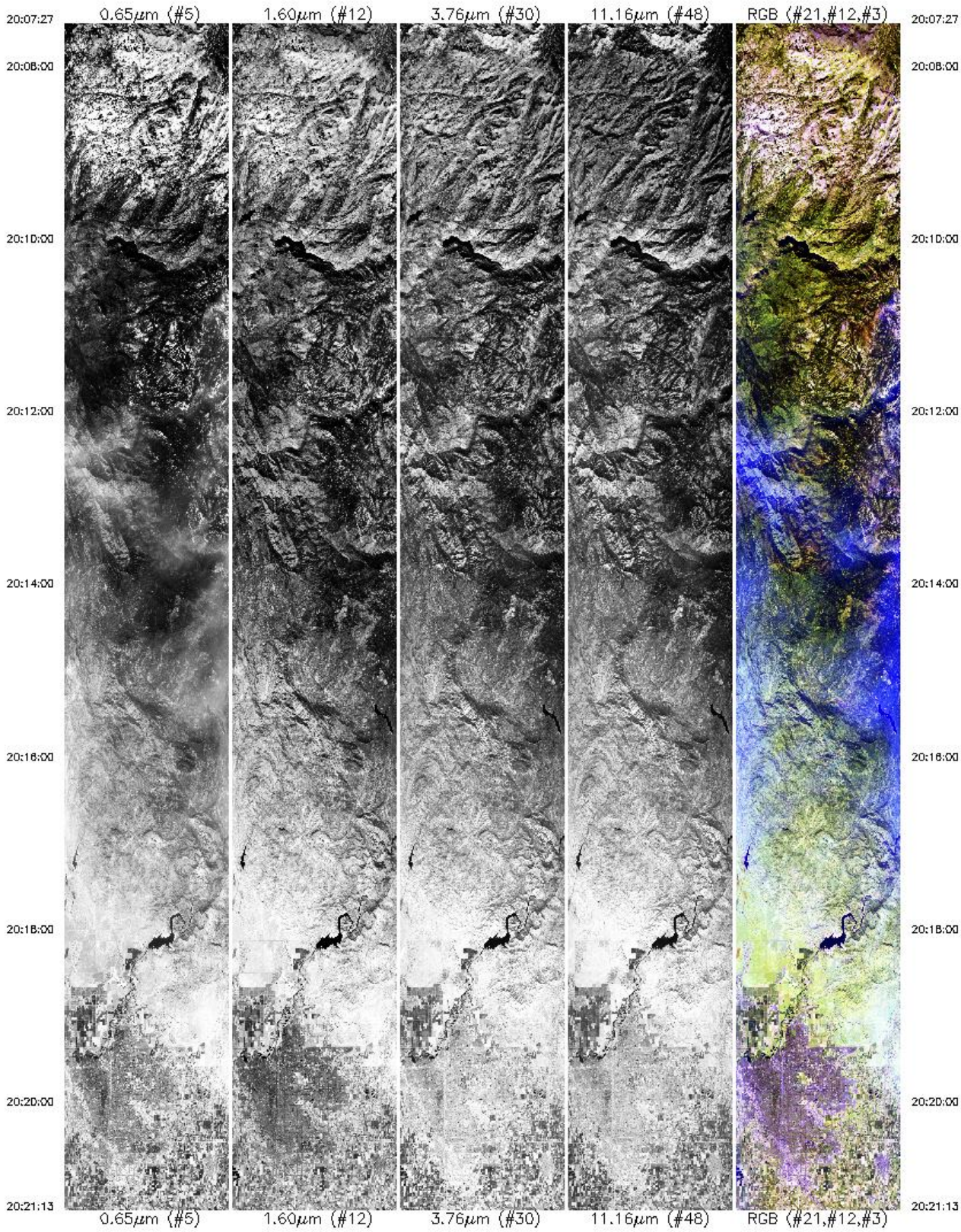

Figure 1. Single-band images and an RGB composite image from flight track 09 acquired on 15 October 2020 near Yosemite National Park, California, U.S. Source: MASTERL1B_2190600_09_20201015_2007_2021_V01.jpg

Citation

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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 spectral data were collected as part of the Western Diversity Time Series (WDTS, formerly HyspIRI) program during nine flights aboard a NASA ER-2 aircraft over selected areas of California, U.S, from 2020-09-17 to 2020-10-15. The WDTS program will observe California's ecosystems and provide critical information on natural disasters such as volcanoes, wildfires, and drought. MASTER products can identify vegetation type and health and provide a benchmark for the state of the ecosystems against which future changes can be assessed. 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 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 deployment, 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. The primary goal of this airborne campaign was to demonstrate important science and applications research that is uniquely enabled the full suite of MASTER thermal infrared bands as well as the contiguous spectroscopic measurements of the AVIRIS (also flown in similar campaigns), or combinations of measurements from both instruments.

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 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, U.S.

Spatial Resolution: 50 m

Temporal Coverage: 2020-09-17 to 2020-10-15

Temporal Resolution: One-time estimate

Study Area: Latitude and longitude are given in decimal degrees.

Site	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
California, U.S.	40.980	31.952	-112.498	-123.750

Data File Information

This dataset includes a total of 732 data files: 90 files in Hierarchical Data Format (HDF-4; *.hdf) format, 332 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 83 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 83 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 36 text (*.txt) files, 9 archives of text files that are zipped (*.zip), 9 flight maps as GIF (*.gif) images, and 90 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” refers to a segment of a given flight. The number of flight tracks varies among flights (Table 2).

- There are 9 flights with 90 flight tracks.
- For each of 90 flight tracks, there is one L1B data file in HDF-4 format and one auxiliary browse image (*.jpg).
- L2 data are included for 83 of the 90 flight tracks. For each track, there is one L1B 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: 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**.hdf (e.g., MASTERL1B_2190600_12_20201015_2119_2152_V01.hdf).

The flight track-level browse images are named MASTERL**AA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH**_V0**J**.jpg (e.g., MASTERL1B_2190600_12_20201015_2119_2152_V01.jpg).

The deployment-level auxiliary files are named MASTER_**BBBBBBBB_YYYYMMDD_X**.**ext** (e.g., MASTER_2190600_20201015_config.txt).

Elements of file names are described as:

AA = "1B", indicates L1B data level,
BBBBBBBB = "1865700" or "1866100", indicating the flight number,
CC = flight track,
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", "gif", "jpg", "kmz", "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	90	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	83	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	83	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	83	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*_V0*J*-location.zip	L2	ENVI	83	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_*BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH*_V0*J*-QAmap.zip	L2	ENVI	83	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	83	Map of land surface temperature (TES LST) in degrees Kelvin.
Auxiliary Files				
MASTERLAA_*BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*.jpg	L1B	JPEG	90	Browse figures; one image per flight track; multiple tracks per flight.
MASTER_*BBBBBBBB_YYYYMMDD*_ancillary.txt	-	Text	9	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_*BBBBBBBB_YYYYMMDD*_config.txt	-	Text	9	Instrument configuration information for flight.
MASTER_*BBBBBBBB_YYYYMMDD*_flightpath.gif	-	GIF	9	Map showing flight paths.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_band_info.txt	-	Text	9	Spectral band information for flight.
MASTER_*BBBBBBBB_YYYYMMDD*_spectral_response_table.zip	-	Text	9	Spectral response tables by band (ZIP archive of 50 text files).
MASTER_*BBBBBBBB_YYYYMMDD*_summary.txt	-	Text	9	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 files contain swath trajectory data using longitude and latitude coordinates. The spatial resolution ranges from 44 to 50 m and is a function of aircraft altitude.

Table 2. Flight track details for each MASTER flight during this 2020 deployment over California (CA) and Nevada (NV), U.S.

Date	Flight Number	Locations (USA)	Flight Tracks	
		Data Level	L1B	L2
2020-09-17	2095500	Salton Sea / Bobcat Fire, CA	7	7
2020-09-24	2095600	Lake Tahoe / Soda Straw / Creek Fire, CA	14	12
2020-09-25	2095700	Soda Straw / Creek Fire, CA	1	0
2020-09-30	2095800	oda Straw / Creek Fire / Santa Barbara, CA	12	12
2020-10-05	2190100	Ivanpah / Mt. Pass, CA / NV	11	10
2020-10-06	2190200	Ivanpah / Mt. Pass, CA / NV	10	10
2020-10-07	2190300	Southern California / Bobcat Fire	10	9
2020-10-13	2190500	San Francisco Bay Area / Soda Straw / Creek Fire, CA	13	11
2020-10-15	2190600	Yosemite / Soda Straw / Creek Fire, CA	12	12
		Total	90	83

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 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). The data storage system and overall system integration were also provided by the ASF.

The MASTER instrument is similar to the MODIS Airborne Simulator 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.

The Western Diversity Time Series (WDTS, formerly HyspIRI) program will observe California’s ecosystems and provide critical information on natural disasters such as volcanoes, wildfires, and drought. It will provide a benchmark on the state of the ecosystems against which future changes can be assessed, as the instruments will be capable of identifying vegetation type and health. The WDTS Airborne Campaign is a multi-year effort to collect seasonal VIS-SWIR and TIR airborne scanner data using both AVIRIS and MASTER remote sensing instruments aboard the ER-2 high-altitude platform (ASF, 2021).

For this deployment, the MASTER instrument was flown on NASA's ER-2 aircraft at altitudes of 19,080–20,215 m above sea level.

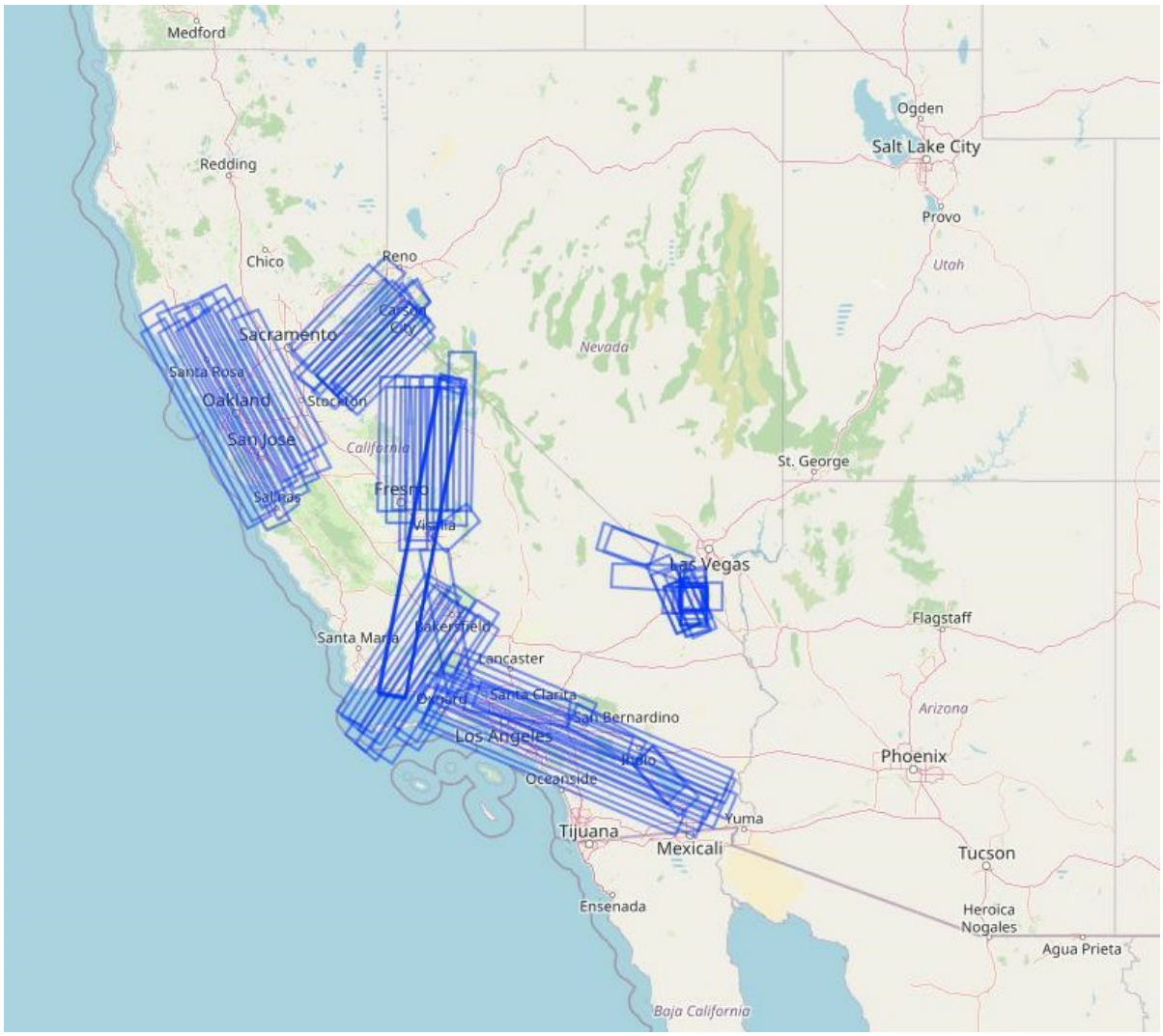

Figure 2. Flight tracks over California, Arizona, and Nevada, U.S., represented as rectangular polygons. Basemap: © OpenStreetMap contributors.

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).

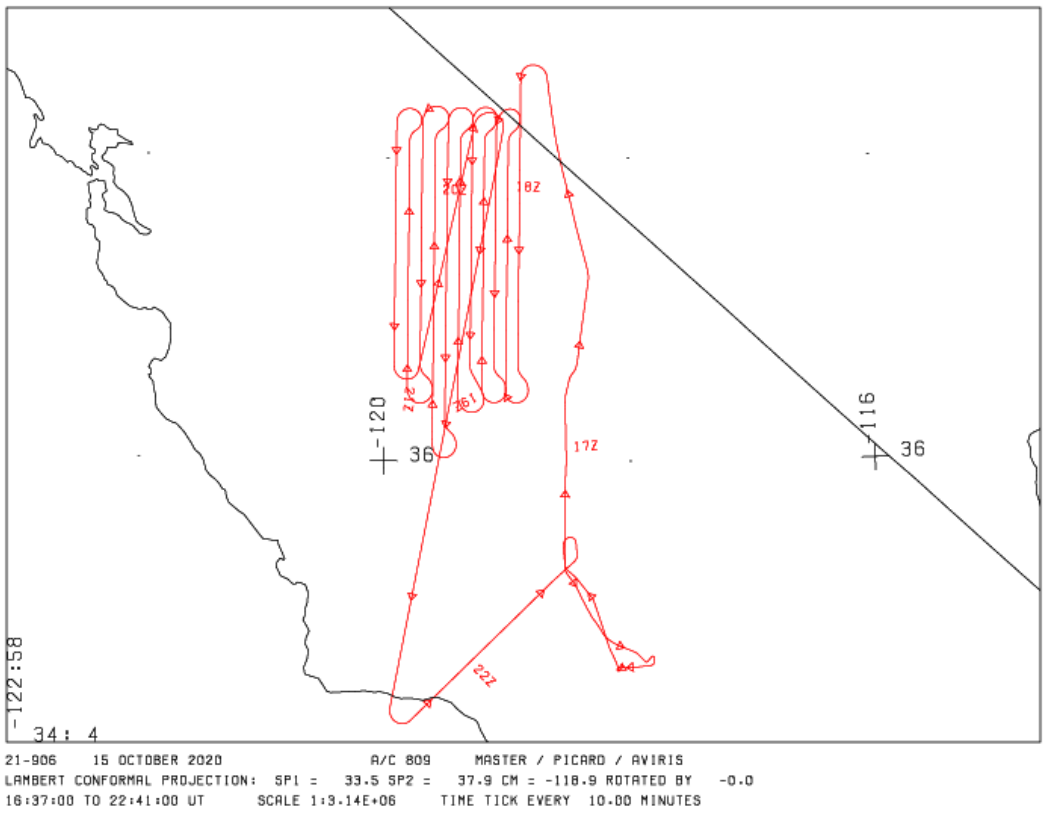

Figure 3. Typical flight path is shown for 2020-10-15. Flight 2190600 and 12 flight tracks. Source: MASTER_2190600_20201015_flightpath.gif

6. Data Access

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

MASTER: Western Diversity Time Series Campaign, WDTS, California, USA, Fall 2020

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 Journal of 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
1.2	2023-02-23	Level 2 files added to dataset. User Guide updated.
1.1	2022-06-22	Companion files from prior release were moved into data. Title was revised, and the User Guide was updated. Content of primary data files is unchanged.
1.0	2021-07-21	Original release.