

MASTER: HypsIRI Airborne Campaign, California and Nevada, Summer 2016

Documentation Revision Date: 2023-04-13

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 data were collected as part of the Hyperspectral Infrared Imager (HyspIRI) mission's preparatory airborne campaign during 6 flights aboard a NASA ER-2 aircraft over California and Nevada, U.S., from 2016-06-09 to 2016-06-21. 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. The primary goal of this airborne campaign was to demonstrate important science and applications research that is uniquely enabled by HyspIRI-like data, taking advantage of the full suite of MASTER thermal infrared bands as well as the contiguous spectroscopic measurements of the AVIRIS (also flown in the HyspIRI campaign), or combinations of measurements from both instruments.

This dataset includes a total of 525 data files: 66 files in Hierarchical Data Format (HDF-4; *.hdf) format, 204 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 102 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 51 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 24 text (*.txt) files, 6 archives of text files that are zipped (*.zip), 6 flight maps as GIF (*.gif) images, and 66 browse images in JPEG (*.jpg) format.

ASTER/MODIS Airborne Simulator Browse Imagery
HyspIRI_2016 Campaign – 09 Jun 2016
Lake Tahoe Box (Line 11)
Flight #16-626-00 Track #1

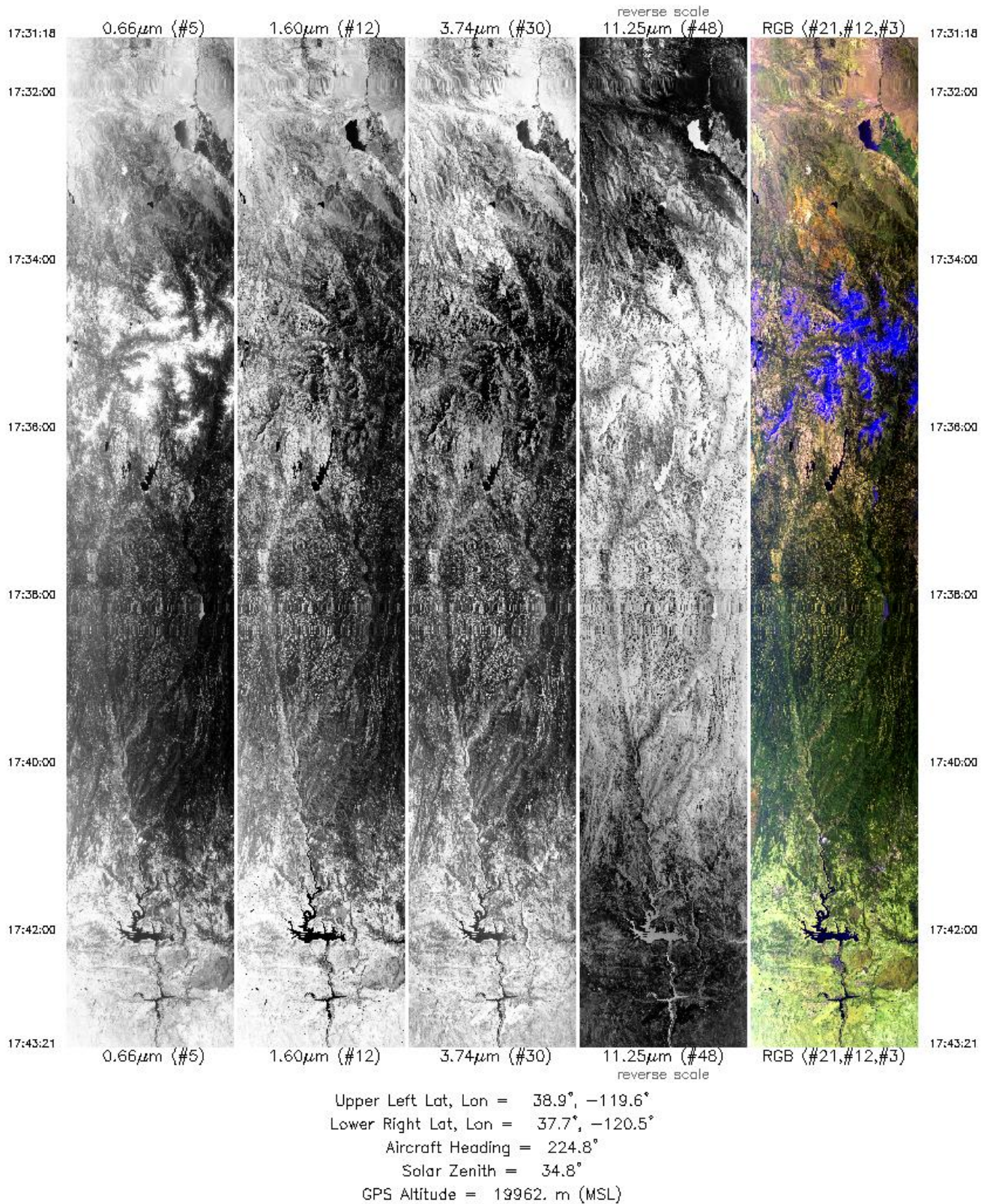


Figure 1. Single-band images and an RGB composite image from flight track 1 as acquired on 09 June 2016 near Lake Tahoe, U.S. Source: MASTERL1B_1662600_01_20160609_1731_1743_V01.jpg

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 data were collected as part of the Hyperspectral Infrared Imager (HyspIRI) mission's preparatory airborne campaign during 6 flights aboard a NASA ER-2 aircraft over California and Nevada, U.S., from 2016-06-09 to 2016-06-21. 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. The primary goal of this airborne campaign was to demonstrate important science and applications research that is uniquely enabled by HyspIRI-like data, taking advantage of the full suite of MASTER thermal infrared bands as well as the contiguous spectroscopic measurements of the AVIRIS (also flown in the HyspIRI campaign), 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](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 and Nevada, U.S.

Spatial Resolution: 44 to 51 m

Temporal Coverage: 2016-06-09 to 2016-06-21

Temporal Resolution: One-time estimate

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
California; Nevada	-123.750	-112.500	40.980	31.952

Data File Information

This dataset includes a total of 525 data files: 66 files in Hierarchical Data Format (HDF-4; *.hdf) format, 204 ENVI raster files (*.dat and *.hdr) that are compressed (*.zip), 102 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 51 Portable Network Graphics (PNG; *.png) files that are

compressed (*.zip), 24 text (*.txt) files, 6 archives of text files that are zipped (*.zip), 6 flight maps as GIF (*.gif) images, and 66 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 six flights with 66 flight tracks.
- For each of 66 flight tracks, there is one L1B data file in HDF format and one auxiliary browse image (*.jpg).
- L2 data are included for 51 of the 66 flight tracks. For each track, there is one L1B data file in KMZ format, 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 MASTERLAA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_V0J-X.ext (e.g., MASTERL1B_1662600_01_20160609_1731_1743_V01-RGB.kmz).

The flight track-level browse images are named MASTERLAA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_V0J.jpg (e.g., MASTERL1B_1662600_01_20160609_1731_1743_V01.jpg).

The flight-level auxiliary files are named MASTER_BBBBBBBB_YYYYMMDD_X.ext (e.g., MASTER_1662700_20160615_config.txt).

Elements of file names are described as:

AA = "1B" or "2", indicating L1B or L2 data level,
BBBBBBBB = 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", "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	66	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_GGHHV0J-RGB.kmz	L1B	KMZ	51	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	51	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	51	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_V0J-location.zip	L2	ENVI	51	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-LST.kmz	L2	KMZ	51	Map of land surface temperature in degrees Kelvin.
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-QAmap.zip	L2	ENVI	51	QA status for each pixel from TES algorithm, where 1 = divergence

File Name	Level	File Type	Total Files	Description
				and 0 = convergence.
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-surface_temp.zip	L2	ENVI	51	Map of land surface temperature (TES LST) in degrees Kelvin.
Auxiliary Files				
MASTERLAA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_V0J.jpg	L1B	JPEG	66	Browse figures; one per flight track, multiple tracks per flight.
MASTER_BBBBBBBB_YYYYMMDD_ancillary.txt	-	Text	6	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_BBBBBBBB_YYYYMMDD_config.txt	-	Text	6	Instrument configuration information for flight.
MASTER_BBBBBBBB_YYYYMMDD_flightpath.gif	-	GIF	6	Map showing path of flight.
MASTER_BBBBBBBB_YYYYMMDD_spectral_band_info.txt	-	Text	6	Spectral band information for flight.
MASTER_BBBBBBBB_YYYYMMDD_spectral_response_table.zip	-	Text	6	Spectral response tables by band (ZIP archive of 50 text files) for flight.
MASTER_BBBBBBBB_YYYYMMDD_summary.txt	-	Text	6	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-4 and ENV files contain swath trajectory data using longitude and latitude coordinates. The spatial resolution ranges from 44 to 51 m and is a function of aircraft altitude.

Table 2. Number of flight tracks per file data level for each MASTER flight during this 2016 deployment.

Date	Flight Number	Locations (U.S.)	Flight Tracks	
			Data Level	
			L1B	L2
2016-06-09	1662600	Lake Tahoe, CA	11	10
2016-06-15	1662700	Mountain Pass, CA	3	3
2016-06-16	1662800	Southern California	11	8
2016-06-17	1662900	Santa Barbara, CA	11	7
2016-06-20	1663000	San Francisco Bay Area, CA	12	10
2016-06-21	1663100	Soda Straw / Yosemite / San Francisco Bay Area, CA	18	13
Total			66	51

Note: Data for five additional flight tracks from 1662900 are available in the [MASTER: Student Airborne Research Program \(SARP\) campaign, California, USA, 2016](#) dataset.

3. Application and Derivation

The primary mission 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 mission 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).

NASA's HypsIRI orbital mission was planned to observe the world's ecosystems and provide critical information on natural disasters such as volcanoes, wildfires, and drought. The HypsIRI preparatory airborne campaigns leveraged the AVIRIS and MASTER instruments to collect precursor datasets in advance of the HypsIRI orbital mission. The primary goal of this activity was to demonstrate important science and applications research that is uniquely enabled by HypsIRI-like data, taking advantage of the contiguous spectroscopic measurements of the AVIRIS, the full suite of MASTER thermal infrared bands, or combinations of measurements from both instruments.

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 8900–20,300 m above sea level. The study area included portions of southern California and western Nevada (Fig. 2, 3). Flight 1662900 on 2016-06-17 acquired data on 16 flight tracks. Tracks 1-11 were devoted to the HypsIRI campaign, and those data are included herein. Tracks 12-16 were devoted to the Student Airborne Research Program (SARP), and those data are available in the [MASTER: Student Airborne Research Program \(SARP\) campaign, California, USA, 2016](#) dataset.

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).

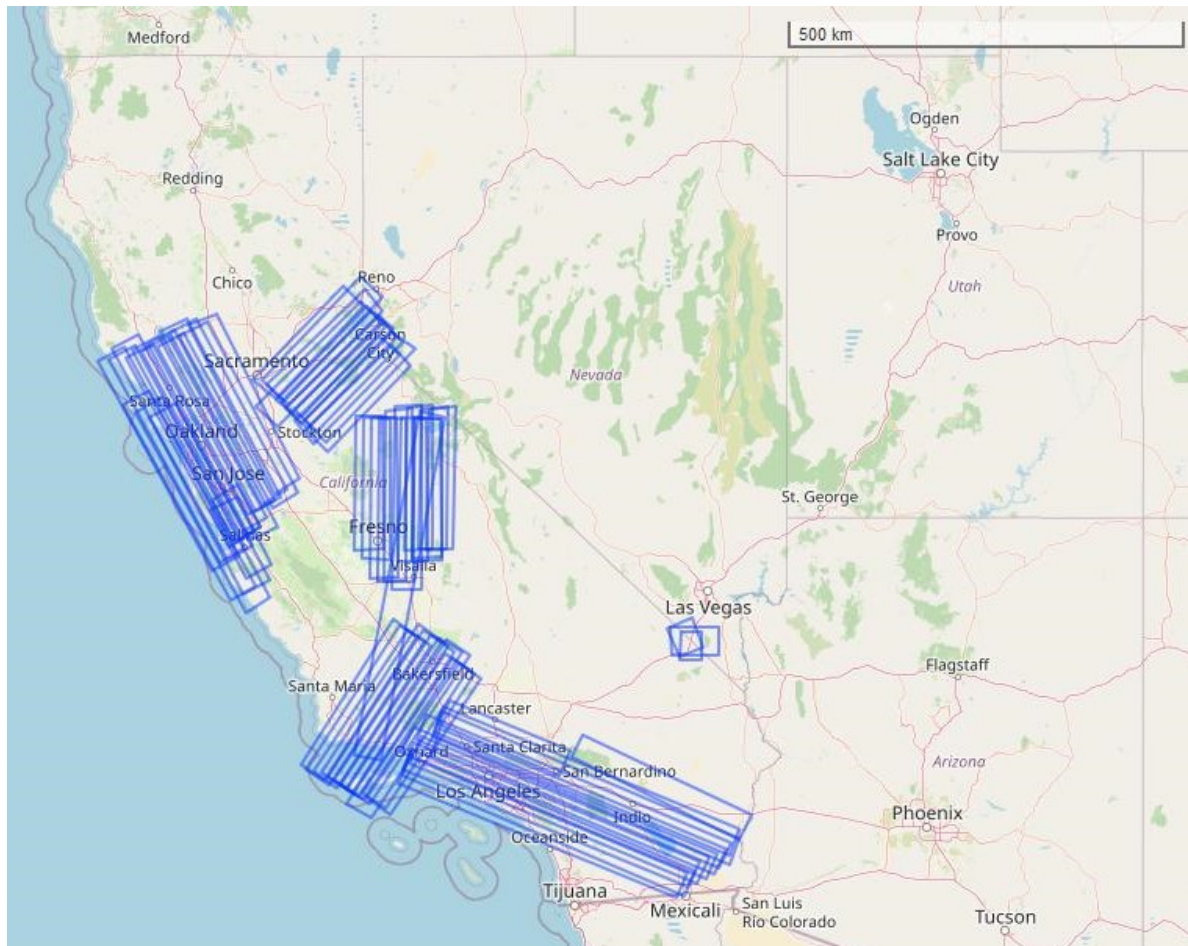


Figure 2. Flight tracks in this dataset represented as rectangular polygons. Map shows southern California and western Nevada, U.S. Basemap: © OpenStreetMap contributors.

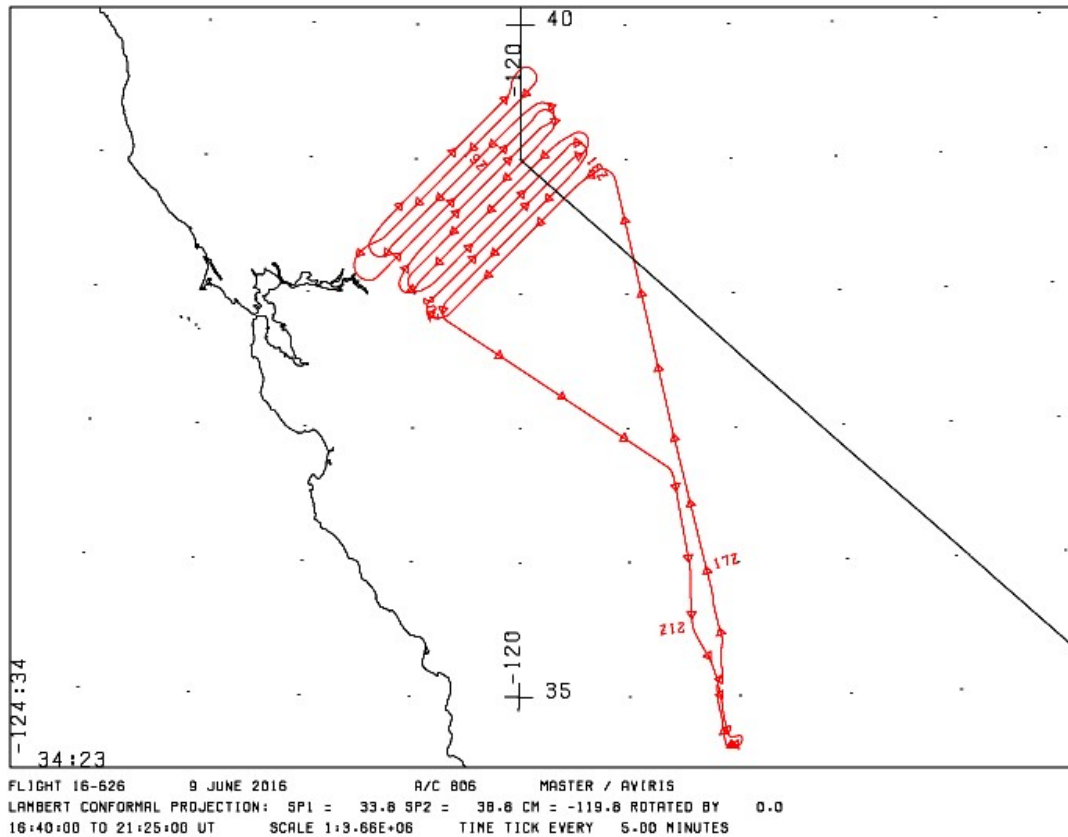


Figure 3. Typical flight path is shown for June 9, 2016. Flight 1662600 and 11 flight tracks. Source: MASTER_1662600_20160609_flightpath.gif

6. References

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7. Dataset Revisions

Version	Release Date	Revision Notes
1.2	2023-01-27	Files from Flight 1662900 have been added to this dataset.
1.1	2022-01-28	Companion files from prior release were moved into data. Title was revised, and the User Guide was updated. Content of data files is unchanged.
1.0	2021-07-21	Original release under title "MASTER (MODIS-ASTER) Airborne Simulator Campaign, California and Nevada, USA, 2016"