MASTER: Western Diversity Time Series Campaign, WDTS, Spring 2025

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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) airborne campaign during seven flights aboard a NASA ER-2 aircraft over California and Nevada, U.S., from 2025-05-27 to 2025-07-17. The WDTS campaign 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 spatial resolution. Derived L2 data products are emissivity in five 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 HDF-5 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 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 554 data files: 64 files in Hierarchical Data Format (HDF-4; *.hdf) format, 64 files in HDF-5 (*.hdf5) format, 256 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 64 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 28 text (*.txt) files, 7 archives of text files that are zipped (*.zip), 7 flight maps as GIF (*.gif) images, and 64 browse images in JPEG (*.jpg) format.

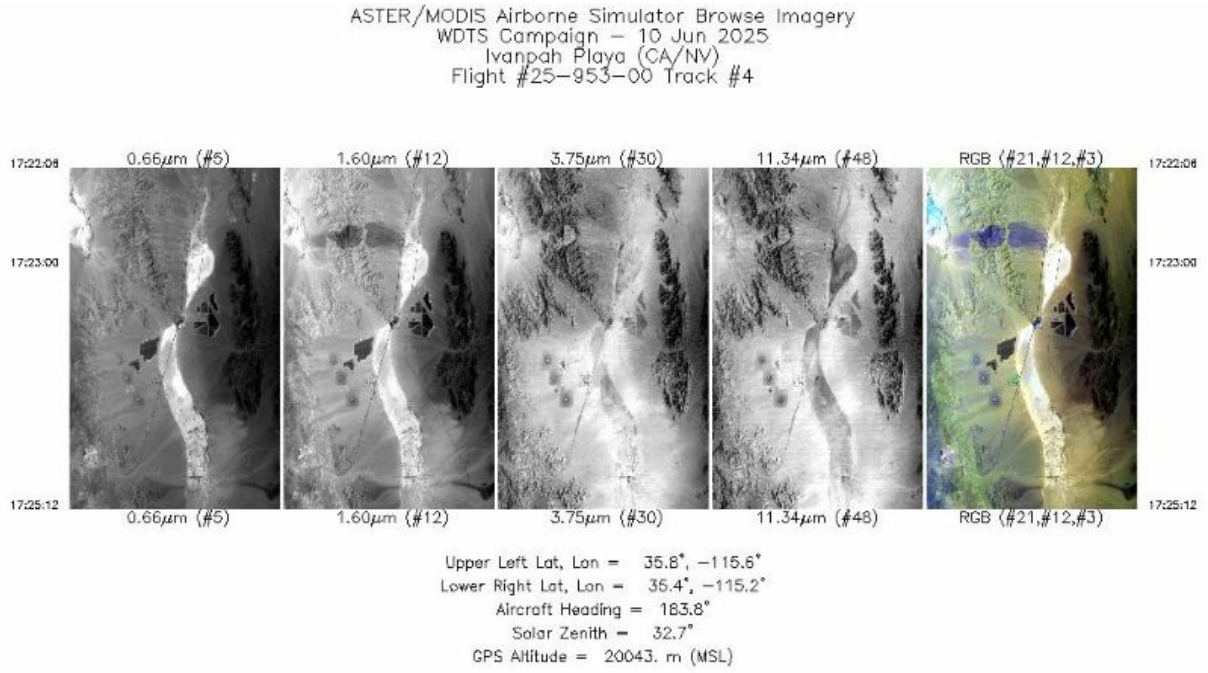

Figure 1. Single band images and an RGB composite image from flight track 4 acquired on 10 June 2025 over Ivanpah Playa on the California-Nevada border in the vicinity of of Primm, NV (approx. 35.60 lat, -115.40 lon). Source: MASTERL1B_2595300_04_20250610_1722_1725_V01.jpg

Citation

Hook, S.J., J.S. Myers, K.J. Thome, M. Fitzgerald, A.B. Kahle, Airborne Sensor Facility NASA Ames Research Center, and R.O. Green. 2025. MASTER: Western Diversity Time Series Campaign, WDTS, Spring 2025. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2471

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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) airborne campaign during seven flights aboard a NASA ER-2 aircraft over California and Nevada, U.S., from 2025-05-27 to 2025-07-17. The WDTS campaign 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 spatial resolution. Derived L2 data products are emissivity in five 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 HDF-5 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 Western Diversity Time Series (WDTS) is a NASA field investigation focusing on observing California's ecosystems and providing critical information on natural disasters such as volcanoes, wildfires, and drought through multispectral imagery. WDTS collects seasonal visible to short wave infrared (VSWIR) and thermal infrared (TIR) airborne imagery using instruments including the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), MODIS/ASTER Airborne Simulator (MASTER), Hyperspectral Thermal Emission Spectrometer (HyTES), and Pushbroom Imager for Cloud and Aerosol Research and Development (PICARD) on a NASA ER-2 high-altitude platform. WDTS aims to provide a benchmark on the state of ecosystems against which future changes can be assessed. WDTS started in 2020 and is a continuation of the HyspIRI Airborne campaign in 2013-2018.

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.

Level 2 data products for this deployment will be added to this dataset when available.

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 and western Nevada, U.S.

Spatial Resolution: 50 m

Temporal Coverage: 2025-05-27 to 2025-07-17

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; western Nevada	39.5185	32.5727	-114.6449	-123.8120

Data File Information

This dataset includes a total of 554 data files: 64 files in Hierarchical Data Format (HDF-4; *.hdf) format, 64 files in HDF-5 (*.hdf5) format, 256 files in Keyhole Markup Language Zipped (KMZ; *.kmz) format, 64 Portable Network Graphics (PNG; *.png) files that are compressed (*.zip), 28 text (*.txt) files, 7 archives of text files that are zipped (*.zip), 7 flight maps as GIF (*.gif) images, and 64 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 seven flights with 64 flight tracks (Table 2).
- For each flight track, there is at least one L1B data file in HDF format, RGB overlays of TIR and VSWIR radiance in KMZ format, and an auxiliary browse image (*.jpg).
- L2 data are included for all flight tracks. For each of these tracks, there are four L2 data files:.
    - One HDF-5 file (*.hdf5) containing L2 data for emissivity, land surface temperature, geographic coordinates, and quality assurance status.
    - One ZIP file containing four L2 PNG files: two RBG composites, single-band emissivity, and land surface temperature.
    - One L2 RGB composite image of emissivity (*emiss-RGB-47-44-43.kmz) in KMZ format.
    - One L2 land surface temperature image (*LST.kmz) in KMZ format.
- For each flight, there is a collection of auxiliary files providing information about the flight and instrument configuration.

The primary data files are named MASTERL1B_**BBBBBBB_CC_YYYYMMDD_EEFF_GGHH**_V0**J**-**X**.**ext** (e.g., MASTERL1B_2594600_01_20250527_1653_1719_V01.hdf, MASTERL2_2594600_01_20250527_1653_1719_V01_B200_SV01.hdf5).

The flight track-level browse images are named MASTERL1B_ **BBBBBBB_CC_YYYYMMDD_EEFF_GGHH**_V0**J**.jpg (e.g., MASTERL1B_2594600_01_20250527_1653_1719_V01.jpg).

The deployment-level auxiliary files are named MASTER_**BBBBBBB_YYYYMMDD_X**.**ext** (e.g., MASTER_2594600_20250527_config.txt).

Elements of file names are described as:

- BBBBBBB = the flight number (see 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 ("1", "2", or "3"),
- X = the file content (see Table 1), and
- ext = "hdf", "hdf5", "kmz", "gif", "jpg", "txt", or "zip", indicating the file format.

The "B200_SV01" element is included in some L2 file names and denotes the build ID and version of the Level 2 processing software employed.

Table 1. File names and descriptions.

File Name	Level	File Type	Total Files	Description
Primary Data Files				
MASTERL1B_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*.hdf	L1B	HDF-4	64	Multispectral radiance at sensor 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.
MASTERL2_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*_B200_SV01.hdf5	L2	HDF-5	64	Five sub datasets: (a) Atmospheric corrected emissivity: Temperature and Emissivity Separation (TES) corrected data in 6 bands (wavelengths: 8.3, 8.62, 9.05, 10.62, 11.31, and 12.11 µm). (b) Land surface temperature (LST) in degrees Kelvin. (c) Latitude and (d) longitude coordinates for pixels. (e) QA status for each pixel from TES algorithm, where 1 = divergence and 0 = convergence.
MASTERL1B_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*-TIR-47-44-43.kmz	L1B	KMZ	64	RGB representation of L1B thermal infrared radiance using bands 47 (red), 44 (green), and 43 (blue).
MASTERL1B_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*-VSWIR-21-12-03.kmz	L1B	KMZ	64	RGB representation of L1B short-wave, visible radiance using bands 21 (red), 12 (green), and 3 (blue).
MASTERL2_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*-images.zip	L2	PNG	64	Four non-georeferenced images: two RGB composites using selected bands, emissivity from a single band, and land surface temperature.
MASTERL2_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J_B200_SV01*-LST.kmz	L2	KMZ	64	Map of land surface temperature in degrees Kelvin.
MASTERL2_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*_B200_SV01-emiss-RGB-47-44-43.kmz	L2	KMZ	64	RGB representation of L2 emissivity using bands 47 (red), 44 (green), and 43 (blue).
Auxiliary Files				
MASTERL1B_*BBBBBBB_CC_YYYYMMDD_EEFF_GGHH*_V0*J*.jpg	L1B	JPEG	64	Browse figures; one image per flight track; multiple tracks per flight.

File Name	Level	File Type	Total Files	Description
MASTER_*BBBBBBB*_*YYYYMMDD*_ancillary.txt	-	Text	7	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_*BBBBBBB*_*YYYYMMDD*_config.txt	-	Text	7	Instrument configuration information for flight.
MASTER_*BBBBBBB*_*YYYYMMDD*_flightpath.gif	-	GIF	7	Map showing flight paths.
MASTER_*BBBBBBB*_*YYYYMMDD*_spectral_band_info.txt	-	Text	7	Spectral band information for flight.
MASTER_*BBBBBBB*_*YYYYMMDD*_spectral_response_table.zip	-	Text	7	Spectral response tables by band (ZIP archive of 50 text files).
MASTER_*BBBBBBB*_*YYYYMMDD*_summary.txt	-	Text	7	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 HDF-5 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 for each MASTER flight during this 2025 deployment over California (CA) and Nevada (NV).

Date	Flight Number	Locations (USA)	Flight Tracks	
		Data Level	L1B	L2
2025-05-27	2594600	S.F. Bay Area Box (Line 12)	12	12
2025-05-29	2594700	Santa Barbara Box (Line 1)	11	11
2025-06-02	2594900	Southern California Box (Line 1)	7	7
2025-06-10	2595300	Ivanpah Playa (CA/NV)	8	8
2025-06-27	2595600	Southern California Box (Line 8)	3	3
2025-07-15	2596000	Lake Tahoe Box (Line 11)	12	12
2025-07-17	2596200	Yosemite NEON Box (Line 11)	11	11
		Total	64	64

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_*BBBBBBB*_*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.

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 campaign, the MASTER instrument was flown on NASA's ER-2 aircraft at altitudes of 19,850–20,360 m above sea level.

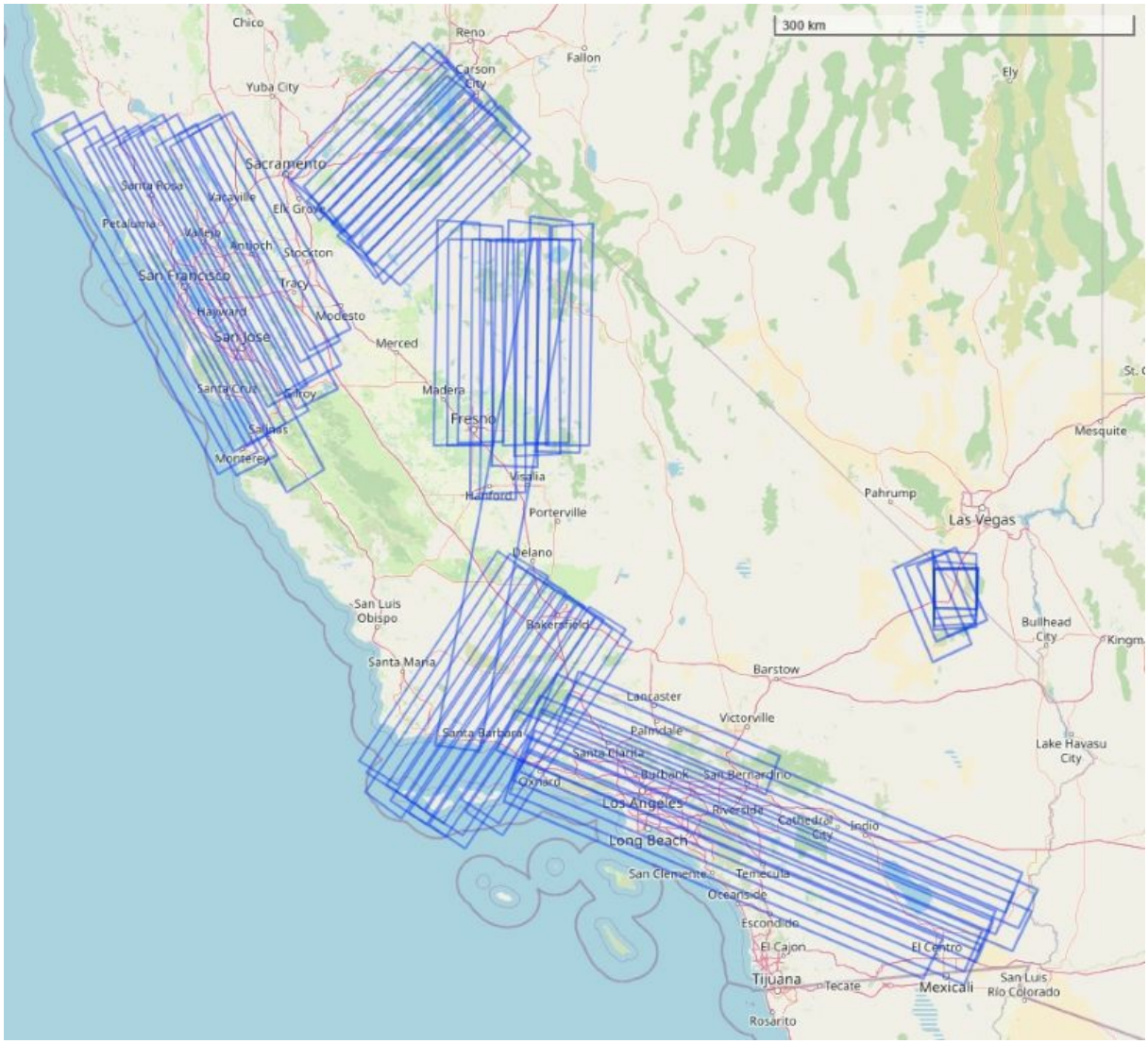

Figure 2. Flight tracks over California and Nevada represented as rectangular polygons. Basemap: © OpenStreetMap contributors.

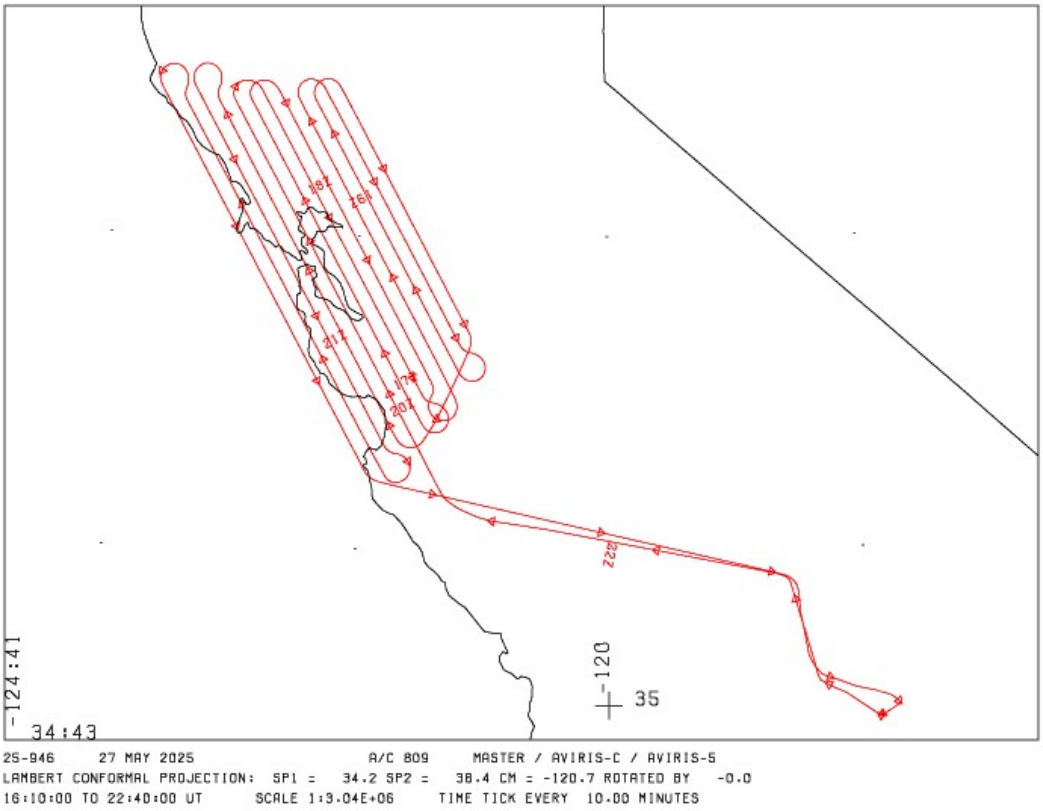

Figure 3. Typical flight path is shown for 27 May 2025. Flight 2594600 and 12 flight tracks occurred over over coastal California in vicinity of San Francisco Bay. Source: MASTER_2594600_20250527_flightpath.gif

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, Spring 2025

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

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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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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