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## MASTER: Airborne Science, Western US, September, 2006

### Get Data

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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 during two flights aboard a NASA ER-2 aircraft over California, Nevada, Wyoming, Utah, Colorado, Nebraska, South Dakota, Wisconsin, and Minnesota, U.S., from 2006-09-19 to 2006-10-13. 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.

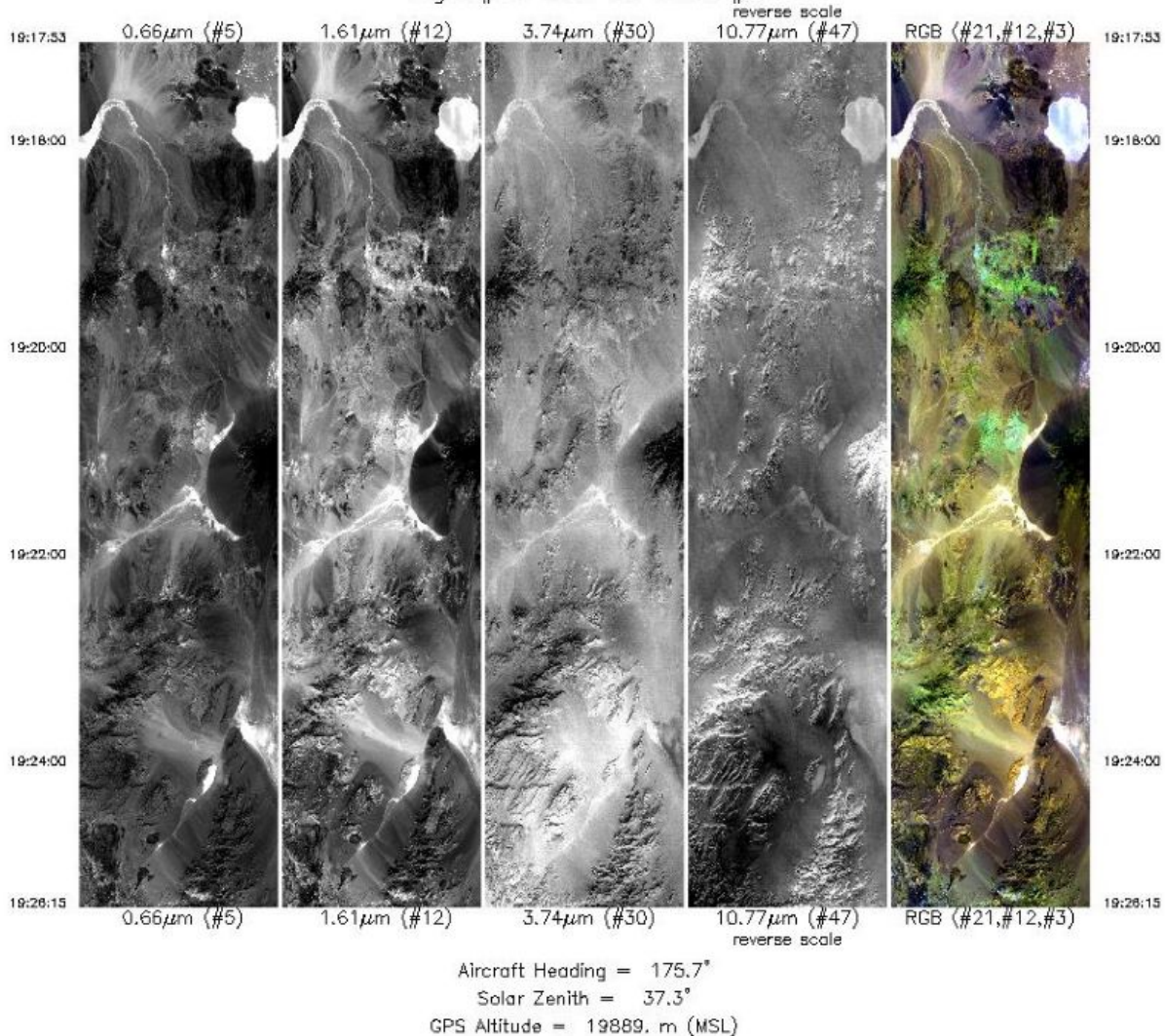
The MASTER instrument is a modified Daedalus Wildfire scanning spectrometer that flies on a variety of multi-altitude research aircraft and provides spectral information similar to that provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission 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  $\mu\text{m}$ ). 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 632 data files: 121 files in Hierarchical Data Format (HDF-4; \*.hdf) format, 220 ENVI raster files (\*.dat and \*.hdr) that are compressed (\*.zip), 55 files in Keyhole Markup Language Zipped (KMZ; \*.kmz) format, 55 Portable Network Graphics (PNG; \*.png) files that are compressed (\*.zip), 40 text (\*.txt) files, 10 archives of text files that are zipped (\*.zip), 10 flight maps as GIF (\*.gif) images, and 121 browse images in JPEG (\*.jpg) format.

ASTER/MODIS Airborne Simulator Browse Imagery  
DFRC\_Sep\_2006 Campaign – 20 Sep 2006

Cuprite

Flight #06-627-00 Track #2



Single-band images and a RGB composite image from flight track 2 as acquired on 20 September 2006 northwest of Beatty, Nevada, U.S. Source: MASTERL1B\_0662700\_02\_20060920\_1917\_1926\_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 during two flights aboard a NASA ER-2 aircraft over California, Nevada, Wyoming, Utah, Colorado, Nebraska, South Dakota, Wisconsin, and Minnesota, U.S., from 2006-09-19 to 2006-10-13. This deployment was coordinated by NASA's Dryden Flight Research Center (DFRC), 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  $\mu\text{m}$ ). 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](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, Wyoming, Utah, Colorado, Nebraska, South Dakota, Wisconsin, and Minnesota, U.S.

**Spatial Resolution:** 3 to 11 m

**Temporal Coverage:**2006-09-19 to 2006-10-13

**Temporal Resolution:** One-time estimate

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Southwestern U.S.	127.8868	-90.2258	48.3110	34.2163

**Data File Information**

This dataset includes a total of 632 data files: 121 files in Hierarchical Data Format (HDF-4; \*.hdf) format, 220 ENVI raster files (\*.dat and \*.hdr) that are compressed (\*.zip), 55 files in Keyhole Markup Language Zipped (KMZ; \*.kmz) format, 55 Portable Network Graphics (PNG; \*.png) files that are compressed (\*.zip), 40 text (\*.txt) files, 10 archives of text files that are zipped (\*.zip), 10 flight maps as GIF (\*.gif) images, and 121 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 10 flights, which include 121 flight tracks (Table 2).
- For each of 121 flight tracks, there is one L1B data file in HDF format and one auxiliary browse image (\*.jpg).
- L2 data are included for 55 of the 121 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: 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\_0663200\_23\_20060929\_1205\_1219\_V01.hdf).

The flight track-level browse images are named MASTERLAA\_BBBBBBBB\_CC\_YYYYMMDD\_EEFF\_GGHH\_V0J.jpg (e.g., MASTERL1B\_0663200\_23\_20060929\_1205\_1219\_V01.jpg).

The deployment-level auxiliary files are named MASTER\_BBBBBBBB\_YYYYMMDD\_X.ext (e.g., MASTER\_0663200\_20060929\_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				

File Name	Level	File Type	Total Files	Description
MASTERL1B_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J.hdf	L1B	HDF-4	121	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	55	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	55	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 $\mu m$ ).
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-images.zip	L2	PNG	55	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	55	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-QAmap.zip	L2	ENVI	55	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	55	Map of land surface temperature (TES LST) in degrees Kelvin.
<b>Auxiliary files</b>				
MASTERLAA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_V0J.jpg	L1B	JPEG	121	Browse figures; one per flight track, multiple tracks per flight.
MASTER_BBBBBBBB_YYYYMMDD_ancillary.txt	-	Text	10	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_BBBBBBBB_YYYYMMDD_config.txt	-	Text	10	Instrument configuration information for flight.
MASTER_BBBBBBBB_YYYYMMDD_flightpath.gif	-	GIF	10	Map showing flight paths.
MASTER_BBBBBBBB_YYYYMMDD_spectral_band_info.txt	-	Text	10	Spectral band information.
MASTER_BBBBBBBB_YYYYMMDD_spectral_response_table.zip	-	Text	10	Spectral response tables by band (ZIP archive of 50 text files).
MASTER_BBBBBBBB_YYYYMMDD_summary.txt	-	Text	10	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 ranges from 38 m to 52 m and is a function of aircraft altitude.

**Table 2.** Number of flight tracks for each MASTER flight during this 2006 deployment.

Date	Flight Number	Locations (USA)	Flight Tracks	
			Data Level	
			L1B	L2
2006-09-19	0662600	Sierra Nevada Foothills, California	7	7
2006-09-20	0662700	Southern Sierra Nevada, California and Nevada	2	2
2006-09-22	0662800	Southern Sierra Nevada, California	8	0
2006-09-25	0662900	Nevada / Yellowstone National Park / Utah	19	17
2006-09-26	0663000	Bishop / Owens Valley, California	8	7
2006-09-27	0663100	Central Nevada	4	4
2006-09-29	0663200	Mono Lake, California	23	18
2006-10-02	0760100	Southern Nevada to Wisconsin and Minnesota	21	0
2006-10-10	0760200	Owens Valley, California	5	0
2006-10-13	0760300	Owens Valley, California and Pacific Ocean	24	0
Total			121	55



### 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 19,869 - 20,020 m above sea level.

Data collection included flight lines over Yellowstone National Park on 25 September 2006 (Figure 2).

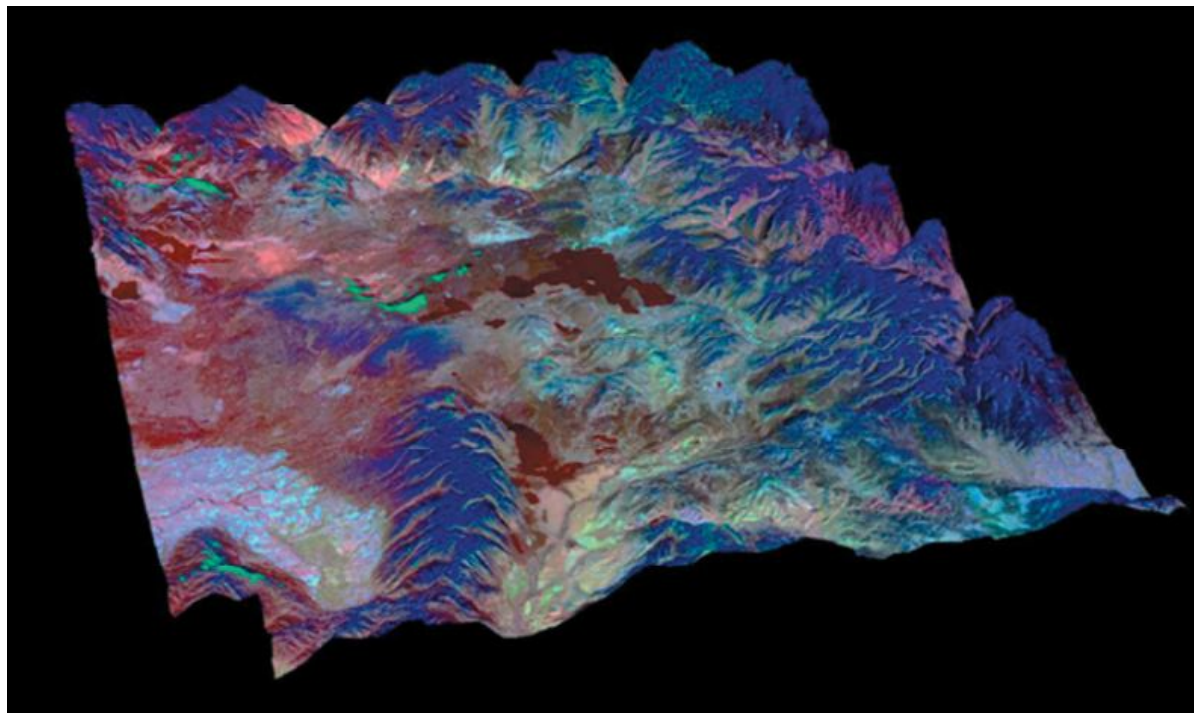


Figure 2. MASTER data acquired on 25 September 2006 over Yellowstone National Park. This is a mosaic of twelve parallel geo-referenced flight lines, draped over a USGS Digital Elevation Model, and is a statistical representation of five spectral bands ranging from 11.0 $\mu$ m to 0.55 $\mu$ m. Source: NASA Suborbital (2006)

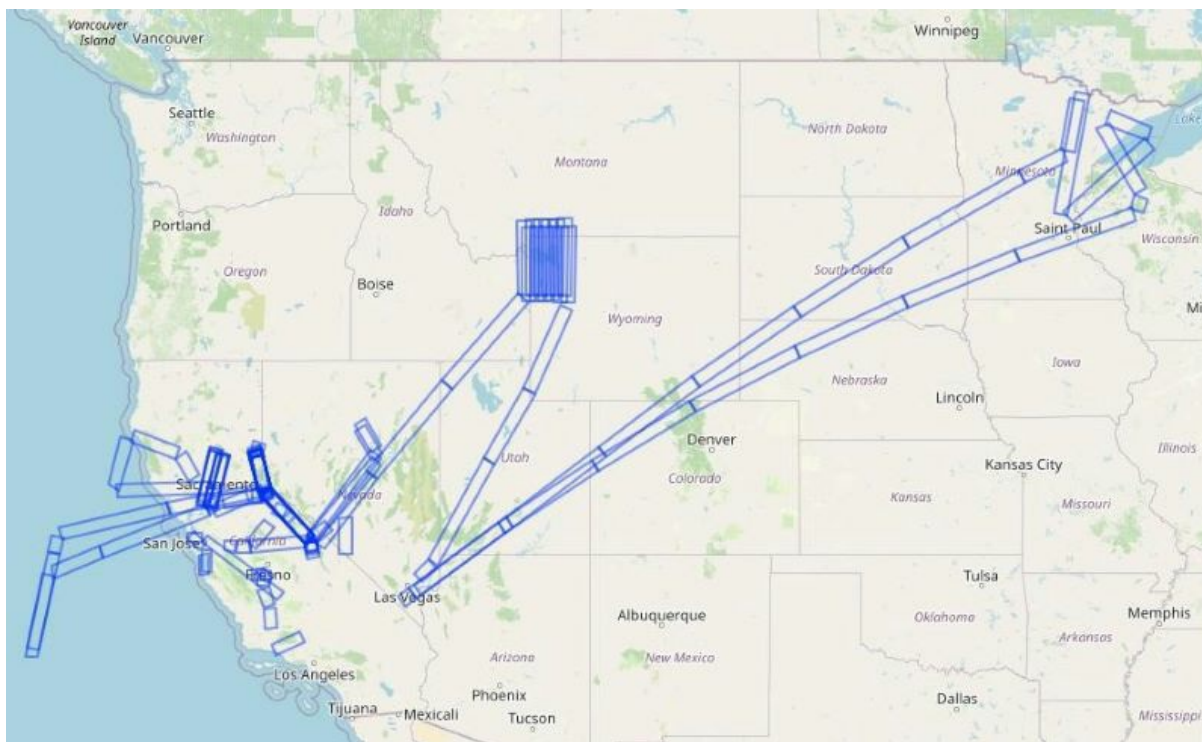


Figure 3. Flight tracks in this dataset represented as blue rectangular polygons. Basemap: © [OpenStreetMap](#) contributors.

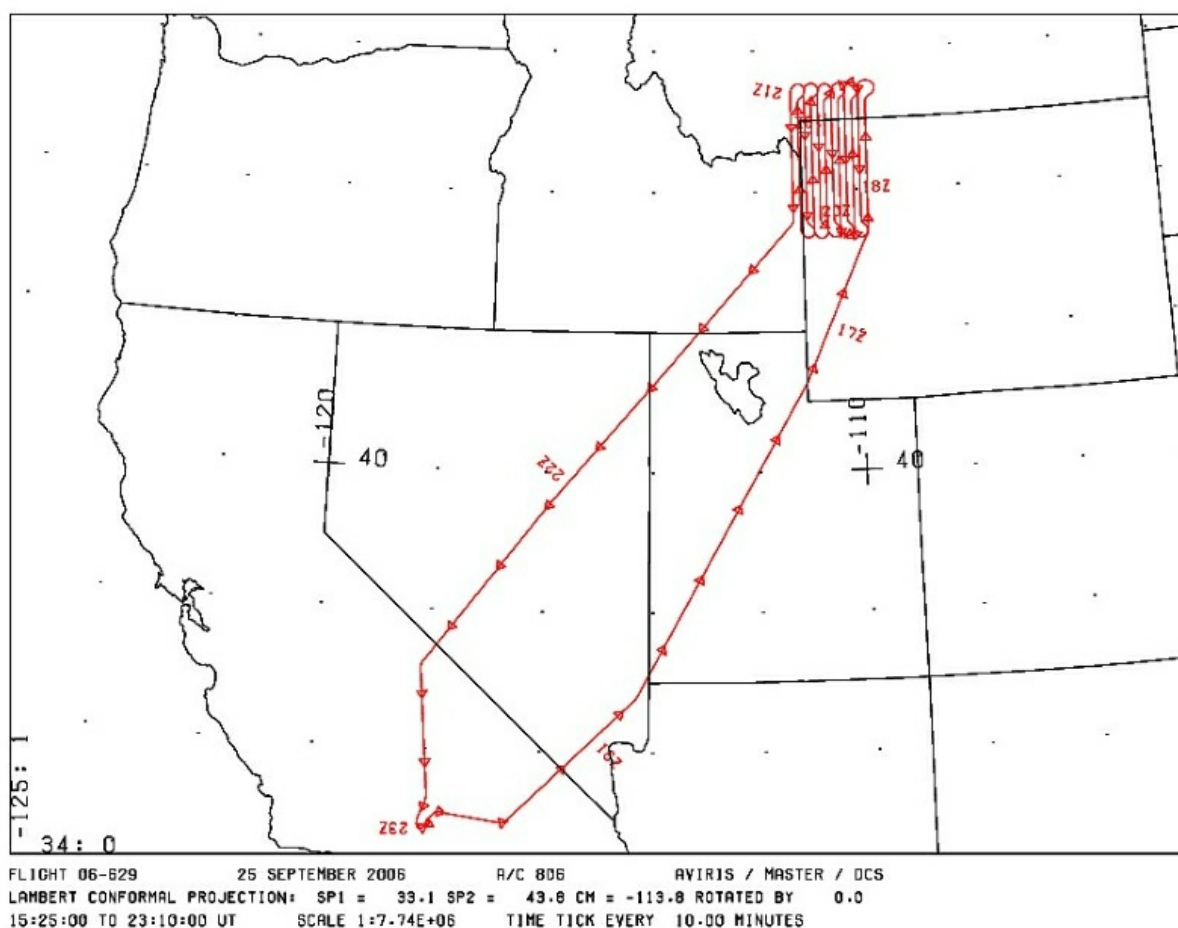


Figure 4. Flight path is shown for 25 September 2006. Flight 0793800 departs from base in California and samples sites in Utah, Yellowstone National Park in Wyoming and Nevada, then returns to base. The flight includes 19 flight tracks. Source: MASTER\_0662900\_20060925\_flightpath.gif

## 6. Data Access

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

[MASTER: Airborne Science, Western US, September, 2006](#)

Contact for Data Center Access Information:

- E-mail: [uso@daac.ornl.gov](mailto:uso@daac.ornl.gov)

- Telephone: +1 (865) 241-3952

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