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## MASTER: HypsIRI Airborne Campaign, Hawaii, 2018

### 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 as part of the Hyperspectral Infrared Imager (HypsIRI) airborne campaign during 12 flights aboard a NASA ER-2 aircraft over Hawaii and southern California, U.S., from 2018-01-11 to 2018-02-20. This campaign includes imagery of Hawaii's volcanoes. 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 HypsIRI-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 HypsIRI campaign), or combinations of measurements from both instruments.

This dataset includes a total of 942 data files: 120 files in Hierarchical Data Format (HDF-4; \*.hdf) format, 360 ENVI raster files (\*.dat and \*.hdr) that are compressed (\*.zip), 180 files in Keyhole Markup Language Zipped (KMZ; \*.kmz) format, 90 Portable Network Graphics (PNG; \*.png) files that are compressed (\*.zip), 48 text (\*.txt) files, 12 archives of text files that are zipped (\*.zip), 12 flight maps as GIF (\*.gif) images, and 120 browse images in JPEG (\*.jpg) format.

ASTER/MODIS Airborne Simulator Browse Imagery  
HyspIRI\_Volcano Campaign – 30 Jan 2018  
Maui N22\_1  
Flight #18-627-00 Track #13

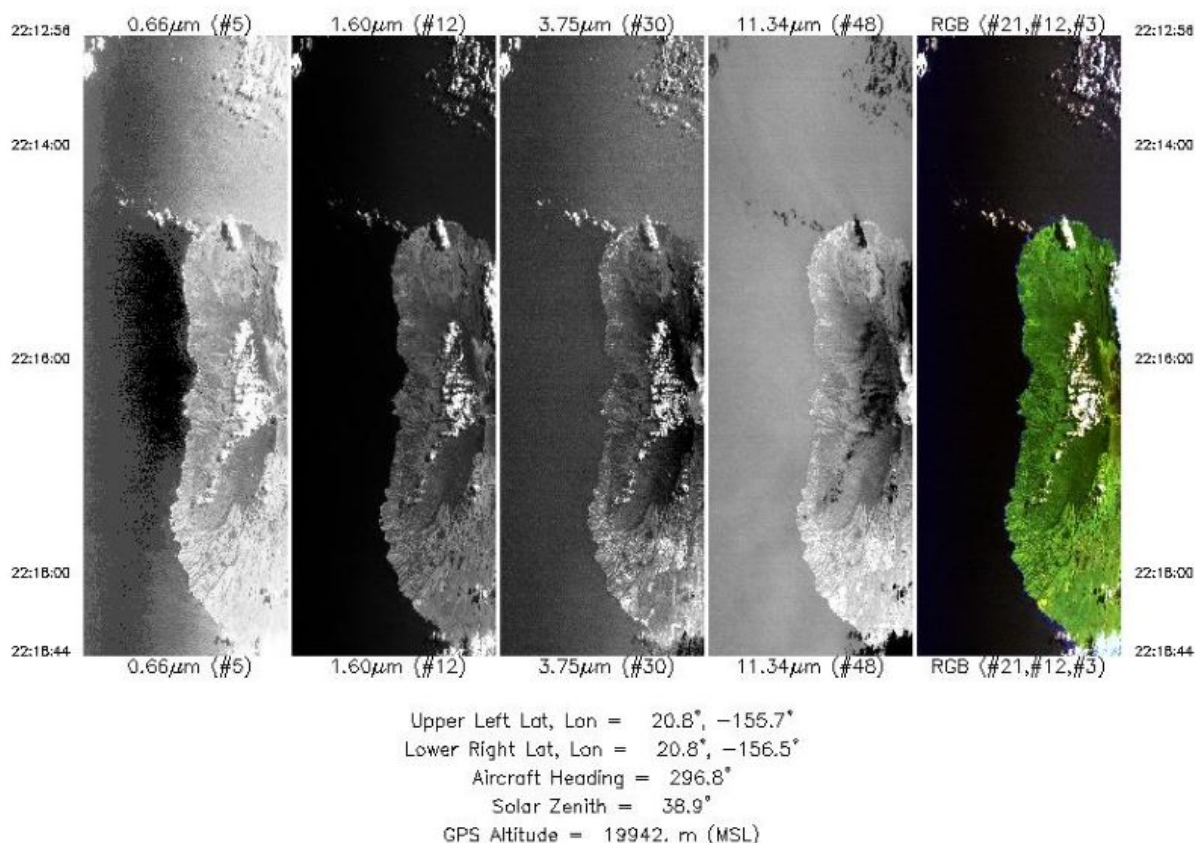


Figure 1. Single-band images and a RGB composite image from flight track 13 as acquired on 30 January 2018 over Maui, Hawaii, U.S. Source: MASTERL1B\_1862700\_13\_20180130\_2212\_2218\_V01.jpg

## Citation

Green, R.O., J.S. Myers, K.J. Thome, M. Fitzgerald, A.B. Kahle, Airborne Sensor Facility NASA Ames Research Center, and S.J. Hook. 2022. MASTER: HyspIRI Airborne Campaign, Hawaii, 2018. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1945>

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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 Hyperspectral Infrared Imager (HyspIRI) airborne campaign during 12 flights aboard a NASA ER-2 aircraft over Hawaii and southern California, U.S., from 2018-01-11 to 2018-02-20. This campaign includes imagery of Hawaii's volcanoes. 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  $\mu\text{m}$ ) 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 Dataset

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:** Hawaiian Islands and southern California, U.S.

**Spatial Resolution:** 19 to 50 m

**Temporal Coverage:** 2018-01-11 to 2018-02-20

**Temporal Resolution:** One-time estimate

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Hawaii and California, U.S.	-158.203	-118.125	36.599	18.633

### Data File Information

This dataset includes a total of 942 data files: 120 files in Hierarchical Data Format (HDF-4; \*.hdf) format, 360 ENVI raster files (\*.dat and \*.hdr) that are compressed (\*.zip), 180 files in Keyhole Markup Language Zipped (KMZ; \*.kmz) format, 90 Portable Network Graphics (PNG; \*.png) files that are compressed (\*.zip), 48 text (\*.txt) files, 12 archives of text files that are zipped (\*.zip), 12 flight maps as GIF (\*.gif) images, and 120 browse images in JPEG (\*.jpg) format (Table 1).

There are different numbers of each type of file, which corresponds to the number of segments of the flight (i.e., a deployment flown on a single day; hereafter "flight track") and whether L2 data were generated (Table 2).

- There are 12 flights with 120 flight tracks (Table 2).
- For each of 120 flight tracks, there is one L1B data file in HDF format and one auxiliary browse image (\*.jpg).
- L2 data are included for 90 of the 120 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\_1862100\_02\_20180111\_2023\_2031\_V01-RGB.kmz).

The flight track-level browse images are named MASTERLAA\_BBBBBBBB\_CC\_YYYYMMDD\_EEFF\_GGHH\_V0J.jpg (e.g., MASTERL1B\_1862100\_02\_20180111\_2023\_2031\_V01.jpg).

The flight-level auxiliary files are named MASTER\_BBBBBBBB\_YYYYMMDD\_X.ext (e.g., MASTER\_1862100\_20180111\_config.txt).

Elements of file names are described as:

AA = "0", "1B", or "2", indicating L0, 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
<b>Primary Data Files</b>				

File Name	Level	File Type	Total Files	Description
MASTERL1B_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J.hdf	L1B	HDF-4	120	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	90	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	90	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	90	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	90	Latitude and longitude coordinates for pixels in ENVI files.
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-LST.kmz	L2	KMZ	90	Map of land surface temperature in degrees Kelvin.
MASTERL2_BBBBBBBB_CC_YYYYmmDD_EEFF_GGHH_V0J-QAmap.zip	L2	ENVI	90	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	90	Map of land surface temperature (TES LST) in degrees Kelvin.
<b>Auxiliary Files</b>				
MASTERLAA_BBBBBBBB_CC_YYYYMMDD_EEFF_GGHH_V0J.jpg	L1B	JPEG	120	Browse figures; one image per flight track; multiple tracks per flight.
MASTER_BBBBBBBB_YYYYMMDD_ancillary.txt	-	Text	12	Ancillary information about flight including notes on aircraft platform, mission objective, and data evaluation.
MASTER_BBBBBBBB_YYYYMMDD_config.txt	-	Text	12	Instrument configuration information for flight.
MASTER_BBBBBBBB_YYYYMMDD_flightpath.gif	-	GIF	12	Map showing path of flight.
MASTER_BBBBBBBB_YYYYMMDD_spectral_band_info.txt	-	Text	12	Spectral band information for flight.
MASTER_BBBBBBBB_YYYYMMDD_spectral_response_table.zip	-	Text	12	Spectral response tables by band (ZIP archive of 50 text files) for flight.
MASTER_BBBBBBBB_YYYYMMDD_summary.txt	-	Text	12	Summary of flight information. Includes 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 19 m 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 the 2018 campaign.

Date	Flight Number	Locations (U.S.)	Flight Tracks	
			Data Level	
			L1B	L2
2018-01-11	1862100 *	Southern California / Thomas Fire Scar	13	12
2018-01-18	1862400	Big Island Hawaii / Oahu	18	16
2018-01-29	1862600	Oahu / Maui / Lanai	9	-
2018-01-30	1862700	Big Island Hawaii / Maui / Lanai	19	19
2018-02-01	1862800	Big Island Hawaii (night)	5	4

Date	Flight Number	Locations (U.S.)	Flight Tracks	
			Data Level	L1B
2018-02-03	1862900	Big Island Hawaii (night)	6	6
2018-02-06	1863000	Big Island Hawaii	9	1
2018-02-08	1863100	Big Island Hawaii (night)	6	6
2018-02-09	1863200	Big Island Hawaii	13	11
2018-02-10	1863300	Big Island Hawaii	9	8
2018-02-12	1863400	Oahu / Lanai / Maui	8	7
2018-02-20	1863500	Big Island Hawaii	5	-
<b>Total</b>			120	90

\* Flight 1862100 over southern California was a functional check flight to ensure all systems were operational prior to deploying to Hawaii.

### 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).

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 campaign 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 (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 instrument was flown on NASA's ER-2 aircraft at altitudes of 8879–20,093 m above sea level.

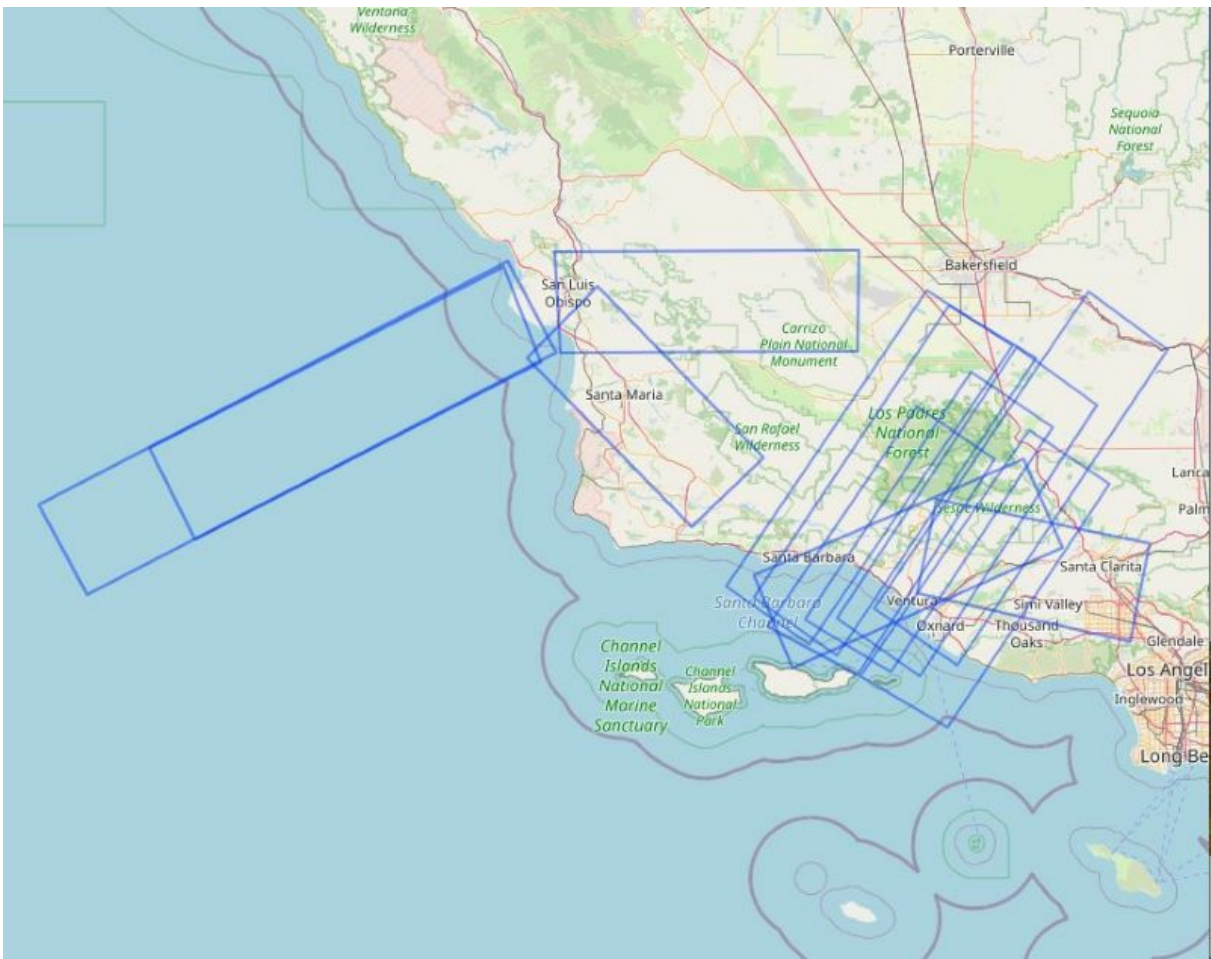


Figure 2. Flight tracks over southern California represented as rectangular polygons. Flight 1862100 was a functional check flight prior to deploying to Hawaii. Basemap: © OpenStreetMap contributors.



Figure 3. Flight tracks over the Hawaiian Islands of Oahu, Maui, represented as rectangular polygons.

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  $\mu\text{m}$ ) and land surface temperature (LST). Emissivity and LST were corrected using a Temperature and Emissivity Separation (TES) algorithm (Coll et al., 2001).

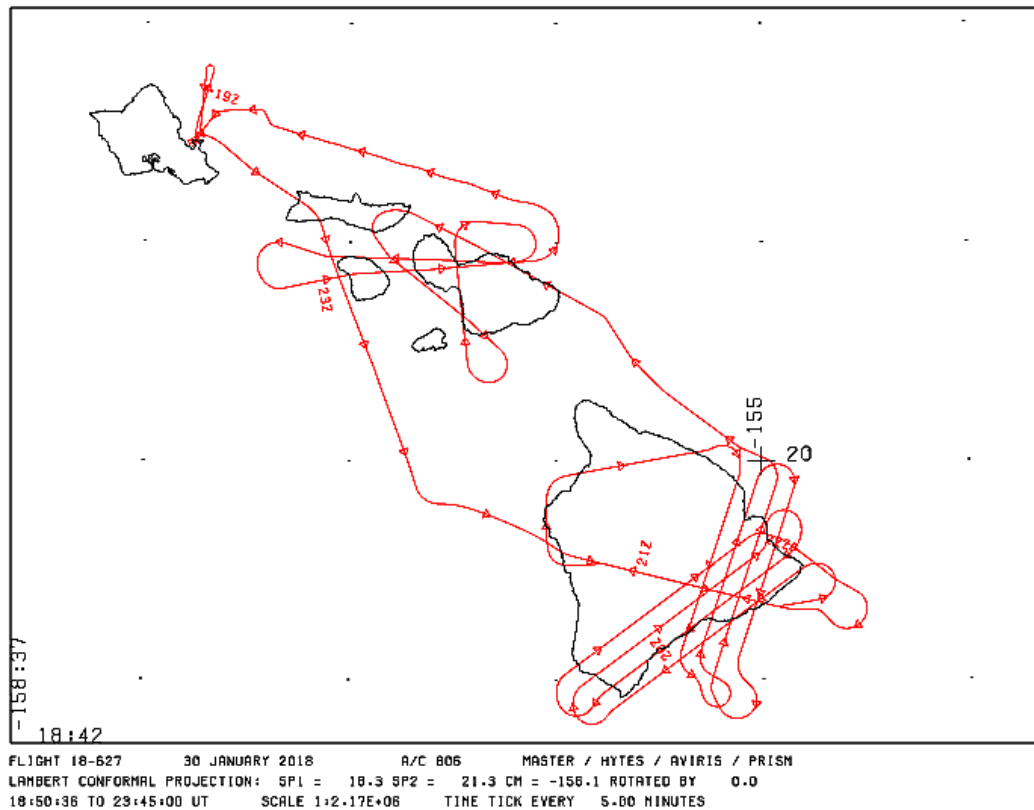


Figure 4. Typical flight path is shown for 30 January 2018 over Hawaii. Flight 1862700 and 19 flight tracks. Source: MASTER\_1862700\_20180130\_flightpath.gif

## 6. Data Access

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

MASTER: HypsIRI Airborne Campaign, Hawaii, 2018

Contact for Data Center Access Information:

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

## 7. References

- ASF. 2021. Campaign summary information: HypsIRI / 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/hypsiri\\_home.html](https://asapdata.arc.nasa.gov/sensors/master/data/deploy_html/hypsiri_home.html)
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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>



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