

MASTER: Level 2 Emissivity and Land Surface Temperature

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Summary

This dataset includes Level 2 (L2) land surface temperature (LST) and spectral emissivity data products derived from the thermal infrared (TIR) bands from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The MASTER L2 TIR products support a wide range of temperature-sensitive applications including wildfire spread mitigation, volcanic eruption detection, agricultural plant stress monitoring, urban heat island characterization, and water system assessment. Emissivity retrievals derived through temperature-emissivity separation enable surface compositional mapping, with demonstrated applications in critical mineral resource identification. Together, these L2 products provide a unique combination of high spatial resolution thermal and compositional information for Earth science research and orbital mission calibration and validation. The L2 TIR data products were derived from L1B georeferenced multispectral imagery of calibrated radiance in the TIR bands (8 - 13 micrometers) at 5 to 50-meter spatial resolution (altitude dependent). The L2 algorithm is based on the ASTER Temperature Emissivity Separation (TES) algorithm in combination with the MODTRAN radiative transfer model to correct for atmospheric effects. Derived L2 data products are the LST and spectral emissivity in six bands (42, 43, 44, 47, 48, 49) that fall within atmospheric windows regions of the TIR. Retrieval of surface emissivity for the remaining TIR bands (45, 46, 50) is not possible since these bands fall in strong ozone and water vapor absorption regions of the spectrum. L2 products are provided in HDF-5 format.

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 Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) (also flown in similar campaigns), or combinations of measurements from both instruments.

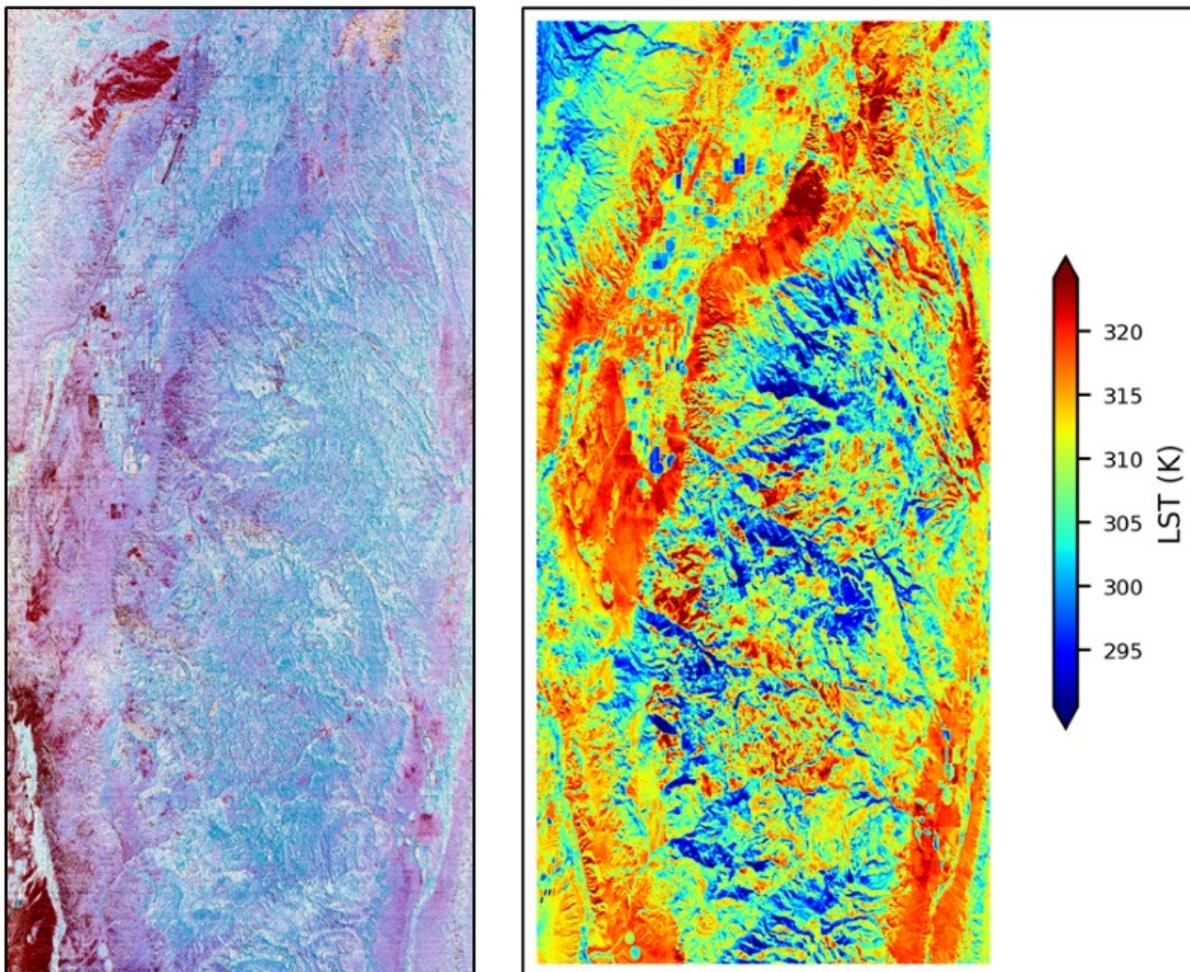


Figure 1. RGB representations of Level 2 emissivity (left; wavelengths: R 10.63, G 9.03, B 8.60 micrometers) and land surface temperature (right; LST

in Kelvin) for MASTER flight scene 2598200_08 acquired on 2025-09-23 over Fishlake National Forest northwest of Marysville, Utah (approximately 38.60 latitude, -112.05 longitude).

Citation

Hulley, G.C., S.J. Hook, T.T. La, and G. Rivera. 2026. MASTER: Level 2 Emissivity and Land Surface Temperature. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/2489>

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1. Dataset Overview

This dataset includes Level 2 (L2) land surface temperature (LST) and spectral emissivity data products derived from the thermal infrared (TIR) bands from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The MASTER L2 TIR products support a wide range of temperature-sensitive applications including wildfire spread mitigation, volcanic eruption detection, agricultural plant stress monitoring, urban heat island characterization, and water system assessment. Emissivity retrievals derived through temperature-emissivity separation enable surface compositional mapping, with demonstrated applications in critical mineral resource identification. Together, these L2 products provide a unique combination of high spatial resolution thermal and compositional information for Earth science research and orbital mission calibration and validation. The L2 TIR data products were derived from L1B georeferenced multispectral imagery of calibrated radiance in the TIR bands (8 - 13 micrometers) at 5 to 50-meter spatial resolution (altitude dependent). The L2 algorithm is based on the ASTER Temperature Emissivity Separation (TES) algorithm in combination with the MODTRAN radiative transfer model to correct for atmospheric effects. Derived L2 data products are the LST and spectral emissivity in six bands (42, 43, 44, 47, 48, 49) that fall within atmospheric windows regions of the TIR. Retrieval of surface emissivity for the remaining TIR bands (45, 46, 50) is not possible since these bands fall in strong ozone and water vapor absorption regions of the spectrum.

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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

Hulley, G.C., S.J. Hook, T.T. La, and G. Rivera. 2026. MASTER: Quicklook Images for Level 2 Emissivity and Land Surface Temperature. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/2488>

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Additional MASTER datasets, including L1B radiance data, are available on the [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: global

Spatial Resolution: 5-50 m (variable; altitude dependent)

Temporal Coverage: 1998-12-02 to present (on-going)

Temporal Resolution: One-time estimate

Data File Information

This dataset holds files in HDF-5 format. Each HDF-5 includes L2 data for emissivity, land surface temperature, geographic coordinates, and quality assurance status.

There is one HDF-5 for each flight track (e.g., scene). 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.

The data files are named MASTERL2_#####_CC_YYYYMMDD_EEFF_GGHH_V0J_B200_SV01.hdf5 (e.g., MASTERL2_2594600_01_20250527_1653_1719_V01_B200_SV01.hdf5).

Elements of file names are described as:

- ##### = the flight number,
- CC = flight track (scene),
- 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"), and
- The "B200_SV01" element denotes the build ID and version of the Level 2 processing software employed.
- Some files have an additional element "_req2" before ".hdf5".

The HDF-5 files contain swath trajectory data using longitude and latitude coordinates. The spatial resolution is approximately 5 to 50 m and is a function of aircraft altitude.

Each HDF-5 contains five subdatasets:

- *Emissivity*: Atmospheric corrected emissivity: 6 bands - band 42 (8.15), 43 (8.59), 44 (9.02), 47 (10.6), 48 (11.32), 49 (12.14 μm); see metadata in HDF5 for wavelengths that were available for temperature emissivity separation (minimum of 3).
- *LST*: Land surface temperature (LST) in degrees Kelvin.
- *Lat*: Latitude coordinate for each pixel in decimal degrees
- *Lon*: Longitude coordinate for each pixel in decimal degrees
- *QAmap*: QA status for each pixel from TES algorithm, where 1 = divergence and 0 = convergence.

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).

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 Level 2 data products include LST and spectral emissivity in six bands: 42 (8.15), 43 (8.59), 44 (9.02), 47 (10.6), 48 (11.32), 49 (12.14 μm) in the thermal infrared range (8 to 13 μm). Retrieval of surface emissivity for the remaining TIR bands (45, 46, 50) is not possible since these bands fall in strong ozone and water vapor absorption regions of the spectrum. The L2 TIR data products were derived from L1B georeferenced multispectral imagery of calibrated radiance in the TIR bands (8 - 13 micrometers) at 5 to 50-meter spatial resolution (altitude dependent). The L2 algorithm is based on the ASTER Temperature Emissivity Separation (TES) algorithm (Gillespie et al., 1998; Sabol et al., 2009) in combination with the MODTRAN radiative transfer model to correct for atmospheric effects. These algorithms take advantage of improvements for stability and also increased spatial resolution of the input atmospheric data.

6. Data Access

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

[MASTER: Level 2 Emissivity and Land Surface Temperature](#)

Contact for Data Center Access Information:

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- Telephone: +1 (865) 241-3952

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