MASTER: Quicklook Images for Level 2 Emissivity and Land Surface Temperature

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Documentation Revision Date: 2026-03-05

Dataset Version: 1

Summary

This dataset holds quicklook images for Level 2 (L2) emissivity and land surface temperature data products derived from the thermal infrared (TIR) bands from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The MASTER L2 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. These quicklooks are provided in PNG image 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.

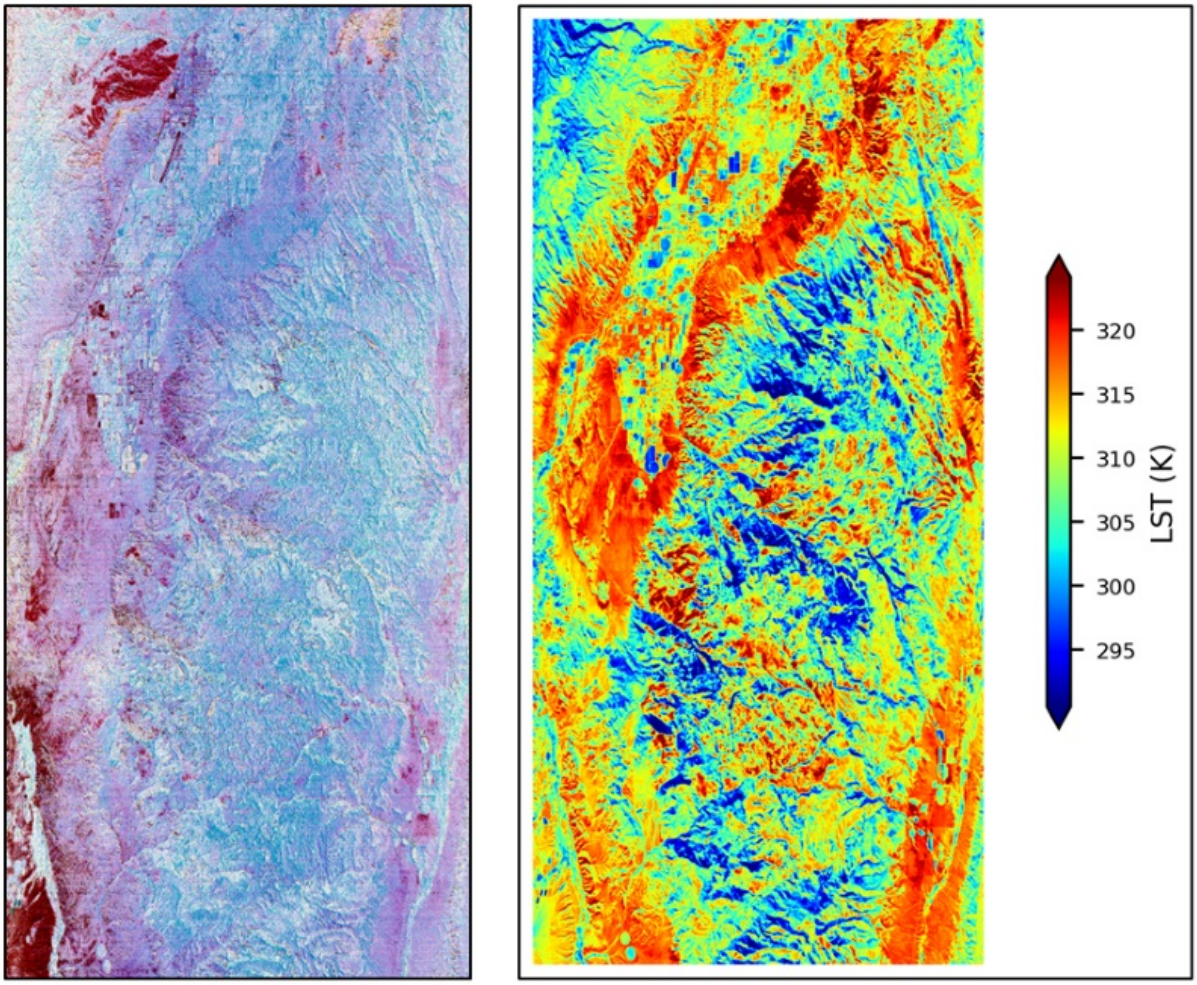

Figure 1. Quicklook (RGB) representations of Level 2 emissivity (left; wavelengths: R 10.63 , G 9.03, B 8.60 micrometers) and land surface temperature (right; LST in Kelvin) for MASTER flight scene 2598200_08 acquired on 2025-09-23 over Fishlake National Forest northwest of Marysvale, Utah (approximately 38.60 latitude, -112.05 longitude). Sources: MASTERL2_2598200_08_20250923_2042_2046_V01_B200_SV01-emiss-RGB-47-44-43.png, MASTERL2_2598200_08_20250923_2042_2046_V01_B200_SV01-LST-colorbar.png

Citation

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

Table of Contents

1. Dataset Overview

This dataset holds quicklook images for Level 2 (L2) emissivity and land surface temperature data products derived from the thermal infrared (TIR) bands from the MODIS/ASTER Airborne Simulator (MASTER) instrument. The MASTER L2 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.

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.

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

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

- The quicklook images represent the emissivity and LST data held in this dataset.

Hulley, G.C., S.J. Hook, T.T. La, and G. Rivera. 2026. MASTER: Image Overlays for Level 2 Emissivity and Land Surface Temperature. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2487

- The KMZ image overlays were derived from the L2 data.

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 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 PNG image format. There are typically three PNG files 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_**BBBBBBB_CC_YYYYMMDD_EEFF_GGHH**_V0**J**_B200_SV01-**KK**.png*, where

- *BBBBBBB* = 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
- *KK* = L2 product (Figures 1 and 2):
  “LST-colorbar”, land surface temperature with colorbar;
  “emiss-colorbar”, emissivity for a single band with colorbar;
  “emiss-RGB-47-44-43”, emissivity from three bands as an RGB composite image.
  Band combinations can be “47-44-43” or “48-47-43”.
- The "B200_SV01" element denotes the build ID and version of the Level 2 processing software employed.

Example file names for a single flight track:
MASTERL2_0300102_01_20021002_1837_1841_V01_B200_SV01-LST-colorbar.png,
MASTERL2_0300102_01_20021002_1837_1841_V01_B200_SV01-emiss-colorbar.png,
MASTERL2_0300102_01_20021002_1837_1841_V01_B200_SV01-emiss-RGB-47-44-43.png

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 Level 2 data products were derived from atmospherically corrected L1B radiance data and include land surface temperature (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 quicklook images represent patterns in the L2 emissivity and LST data provided in the related dataset (Hulley et al., 2026). Three types of quicklook images were generated for each flight track (scene). Emissivity is depicted in a three-band RGB image (Figure 1, left) and for a single band (Figure 2). LST is illustrated with a color bar legend (Figure 1, right).

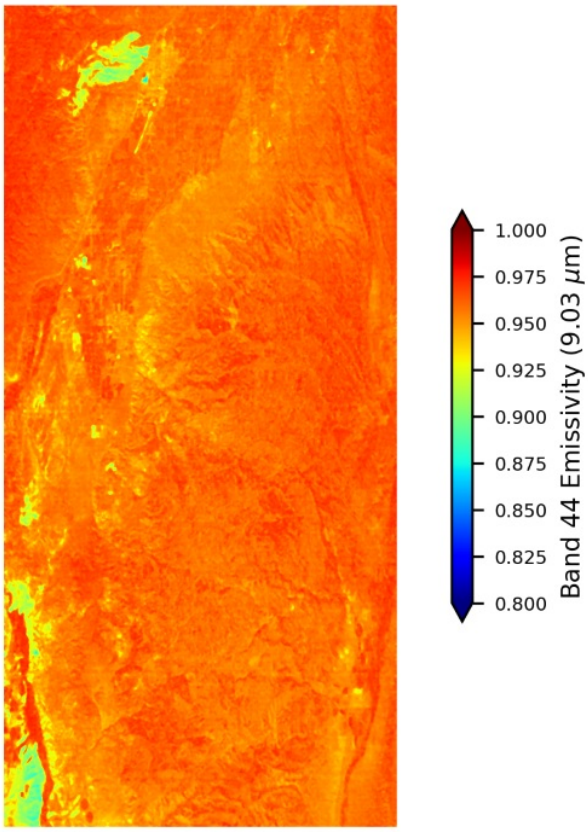

Figure 2. Quicklook image for band 44 emissivity for MASTER flight scene 2598200_08 acquired on 2025-09-23 over Fishlake National Forest northwest of Marysvale, Utah (approximately 38.60 latitude, -112.05 longitude). Source: MASTERL2_2598200_08_20250923_2042_2046_V01_B200_SV01-emiss-colorbar.png.

6. Data Access

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

MASTER: Quicklook Images for Level 2 Emissivity and Land Surface Temperature

Contact for Data Center Access Information:

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

7. References

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