MASTER L3 Elevated Temperature Feature (ETF) and Fire Radiative Power (FRP) Products User Guide

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Revision	Effective Date	Prepared by	Description of Changes
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1. Introduction

The MODIS/ASTER (MASTER) airborne simulator is a collaborative project developed by the Airborne Sensor Facility at NASA Ames Research Center, the Jet Propulsion Laboratory, and the USGS EROS Data Center. Its primary objective is to support the ASTER and MODIS instrument teams in algorithm development, calibration, and validation efforts. MASTER is based on the design of the MODIS Airborne Simulator (MAS) developed by the MODIS project (King et al., 1996), but with key enhancements.

MASTER contains 50 spectral channels: channels 1–25 in the visible to shortwave infrared region, and channels 26–50 in the mid-infrared and thermal infrared regions.

MASTER has an instantaneous field of view of 2.5 milliradians, with pixel size dependent on flight altitude. The instrument can be deployed on a variety of airborne platforms, including the DOE King Air Beechcraft B200, Sky Research Cessna Caravan C208, NASA DC-8, NASA ER-2, and NASA WB-57. These platforms enable the collection of data with pixel sizes ranging from approximately 3 to 50 meters, depending on the aircraft: 5–15 m (B200), 3–15 m (C208), 10–30 m (DC-8), 50 m (ER-2), and 5–50 m (WB-57).

Comprehensive details of the MASTER instrument are provided in (Hook, et al., 2001), whereas additional information, including product ordering, is available at:

https://masterprojects.jpl.nasa.gov/

The MASTER Level 3 product follows the format that was established by NASA Ames, same name convention of MASTER L1B data with the addition of the Build ID and Software Version ID and addition level three nomenclature given different types of level three products.

<Product level name MASTERLn(xxx)>_<Mission number ID>_<scene number (2 digits)>_<date YYYYMMDD>_<start time HHMM>_<end time HHMM>_<Version number VNN>_<Build id number>_<Software version number>-<specific sub product with or without bands>

More details on MASTER Nomenclature/Naming Convention can be found on the MASTER website (https://masterprojects.jpl.nasa.gov/)

2. MASTER L3 ETF Product

The MASTER L3 Elevated Temperature Feature (ETF) derived from the "CalibratedData" Scientific Data Set (SDS) contained in the MASTER L1B product. ETF refers primarily to thermal anomalies in the 500-1200 range, which are typically associated with active fire and volcanic activity that have significant hazards to populations and infrastructures. The algorithm used for ETF detection leverage the differences in the observed radiance between the Mid-InfraRed (MIR: 3-5 µm) and Therma InfraRed (TIR: 10–12 µm) spectral windows. Surfaces affected by active fire or volcanic eruptions generally exhibit temperatures ranging from ~500–1200 K, whit their peak spectral radiance occurring in the MIR region. In contrast, ambient land surface temperatures range from 250 to 320 K, resulting in a peak spectral radiance within the TIR region.

Therefore, by analyzing the differences in the slope of the Planck curve between the MIR and TIR regions, it became possible to distinguish the relative contribution of the hot and ambient thermal components. This is applied using the Normalized Thermal Index (NTI), which quantifies the contrast between the MIR and TIR.

The algorithm used for detecting Elevated Temperature Feature is described in detail in the following publication (Shreevastava, et al., 2023;).

3. MASTER L2 FRP Product

The MASTER L3 Fire Radiative Power (FRP) is calculated using the Brightness Temperature of the pixel where ETF have been detected, by using the signal in the MIR region, where the elevated temperature feature – active fire or volcanic eruption - signal is most intense. It uses the Single Waveband Methods described I Wooster et al., 2005, and first developed by Kaufman et al. (1996, 1998a, 1998b). This approach takes into consideration the radiative brightness temperatures of the fire pixel and the neighboring non-fire background

4. File Formats

MASTER L3ETF product is provided in HDF5 (.hdf5) format and contains three Scientific Data Set (SDS) *Brightness_Temperature*, *Brightness_Temperature_masked*, and *Brightness_Temperature_masked_binary*. Each SDS is stored as al multidimensional array of type float 32, representing Brightness temperature from calibrated radiance measurements in the mid- and thermal infrared region. No scaling factor or offset needs to be applied to any of the datasets. The spatial dimensions correspond to the projection and resolution of the MASTER L1B data, and each layer maintains identical grid alignment, allowing direct pixel-by-pixel comparison.

The *Brightness_Temperature* SDS provides land surface brightness temperature values (in Kelvin) retrieved from the calibrated TIR radiance.

The *Brightness_Temperature_masked* SDS retains the same structure but includes data screening based on the occurrences of ETF. Pixel where ETF were not detected are assigned a fill value of -9999.0, while pixel where ETF were detected preserve the original value in Kelvin.

The *Brightness_Temperature_masked_binay* SDS orivides a binary mask [0, 1] where 1 indicates a pixel with elevated temperature features, and 0 indicate a pixel not characterized by fire or volcanic eruption.

Table 1: Description of Scientific Data Sets (SDS) in the MASTER L3 Products

Product	**SDS**	**Data type**	**Units**	**Scale Factor**	**Offset**
ETF	*Brightness_Temperature*	Float32	Kelvin	n/a	n/a
Description: Calibrated brightness temperature at specific wavelength					
ETF	*Brightness_Temperature_masked*	Float32	Kelvin	n/a	n/a
Description: Calibrated brightness temperature at specific wavelength – for valid pixel					
ETF	*Brightness_Temperature_masked_binary*	Float32	n/a	n/a	n/a
Description:Binary mask (0 = noETF pixel; 1= ETF pixel					
FRP	*Fire_Radiative_Power*	Float32	MW	n/a	n/a
Descritpion: Fire Radiative Power derived from MASTER band 32 and applied for ETF pixel					

5. Examples of MASTER Level 3 Elevate Temperature Feature (L3 ETF) and Fire Radiative Power (L3 FRP) products

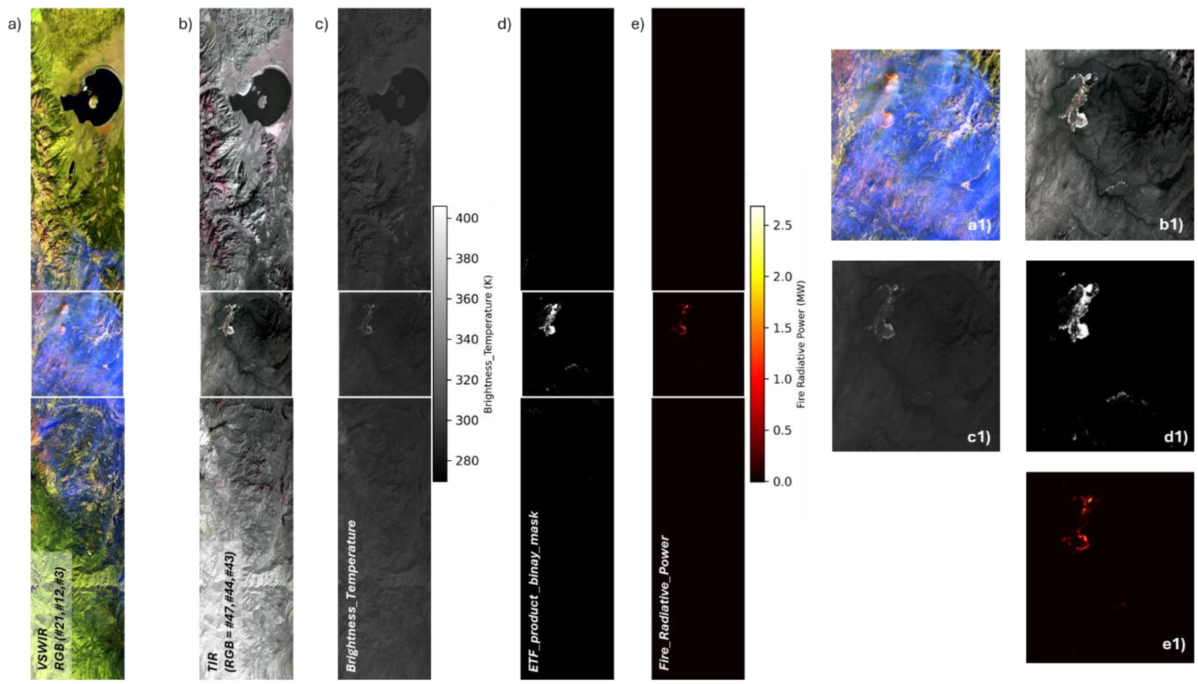

Figure 1: Example of the HyTES Level3 ETF and FRP products for flight line 2190600_03. The flight captured the Creek Fire, which occurred in 2020 from September 4th to December 24th, across Fresno and Madera Counties in central California, US. Panels a) and b) show simply RGB composites of three bands in the VSWIR and TIR windows, respectively. Panels c) and d) present two example layers of the MASTERL3FRP product: Brightness_Temperature and Brightness_Temperature_masked_binary. Panel e) shows the Fire Radiative Power product. a1), b1), c1), d1), and e1), display zoom-in views of the ETF and FRP pixels.

Figure 1 provides an example of the MASTER Level-3 Emissivity Temperature Fire (ETF) and Fire Radiative Power (FRP) products derived from flight line 2190600_03, which observed the Creek Fire in central California. This example illustrates the main data layers and their visualization within the Level-3 products.

The RGB composites shown in panels (a) and (b) demonstrate how the VSWIR and TIR data can be used to visually identify active fire fronts and burned areas. Panels (c) and (d) highlight specific layers from the MASTER L3 ETF dataset, including the Brightness_Temperature and its corresponding binary mask used to isolate valid fire pixels. Panel (e) presents the Fire Radiative Power output, which quantifies the radiative energy emitted by the fire.

The zoomed-in panels (a1–e1) allow a closer inspection of the spatial distribution and consistency of ETF and FRP values over the fire-affected regions, demonstrating the level of detail available in the MASTER data products.

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