# MASTER Level - 3 Surface Mineralogy (SM) Product User Guide


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# Change History Log

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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 follows the format that was established by NASA Ames same naming 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 at the MASTER website (https://masterprojects.jpl.nasa.gov/)

## 2. MASTER L3 SM Product

The MASTER L3 Surface Mineralogy product derived from MASTER Level - 2 Emissivity product and contains information on the presence of specific minerals at the surface derived using the Multiple Endmember Spectral Mixture Algorithm (MESMA). MESMA enables a relatively simple statistical determination of the best-fit end-member percentages for a given mixture spectrum. The spectral library used includes the 10 most abundant minerals on the Earth's surface (andesine, augite, calcite, forsterite, gypsum, hornblende, microcline, muscovite, and quartz), along with a blackbody spectrum to account for differences in spectral depth between the reference spectra and the actual data. Additional bands in the L3 SM \SufaceMineralogy Scientific Data Sets (SDS) include the residual error expressed as root-mean-square (RMS), representing the total residual error across the entire wavelength range, and the per-band residual error. The L3 SM product also includes the Weight Percent Silica (WPS), which maps variations in surface silicate mineralogy based on the shift of the diagnostic silica absorption feature toward longer wavelengths as mineralogy transitions from felsic to mafic compositions

The MESMA algorithm used for the L3 SM product is described in detail in the following publication (Roberts, et al., 1998; Ramsey, et al., 2005).

The WPS algorithm used for the L3 SM product is described in detail in the following publication (Hook, et al., 2005).

## 3. File Formats

MASTER L3 SM product is provided in HDF5 (.hdf5) format and contains the Scientific Data Set (SDS) *SurfaceMineralogy*, which stores information derived from the unmixing of the MASTER L2 emissivity data. The SDS is organized as a multidimensional array of type Float 32, where each layer (band) represents a distinct mineral abundance, the associated quality metric (residual error), and the silica content. No scaling factor or offset needs to be applied to any of the SDS's layers. 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.

Specifically, the first ten layers (indices 0–9) represent the modeled abundances of individual minerals that are part of the reference spectral library (andesine, augite, calcite, forsterite, gypsum, hornblende, microcline, muscovite, quartz), plus a blackbody endmember used for emissivity normalization. These mineral layers/maps are expressed as dimensionless values within the valid range [0–1] for each mineral.

Layers indexed from 10 to 16 provide detailed information about the residuals. The RMS layer reports the overall root mean square fitting error for each pixel, while the B1–B6 Residual Error layers represent the spectral residuals associated with each thermal infrared band used in the unmixing process. These layers help identify areas of low model performance or spectral mismatch.

The last layer of index 17 is the WPS (Weighted Percent Silica), and represents the silica content for each pixel, expressed as percentage (%).

Table 1 (below) summarizes the details of the MASTER Level 3 SM product.

*Table 1: Description of Scientific Data Sets (SDS) in the MASTER L3 SM Product*

| Product | SDS | Data type | Units | Valid Range | Scale Factor | Offset |
|---|---|---|---|---|---|---|
| SMA | *SurfaceMineralogy* | Float32 | n/a | n/a | n/a | n/a |
| **idx** | **Attributes/Layers/Bands** | | | | **Description** | |
| 0 | *andesine* | float32 | n/a | [0 1] | modeled abundance | |
| 1 | *augite* | float32 | n/a | [0 1] | | |
| 2 | *calcite* | float32 | n/a | [0 1] | | |
| 3 | *forsterite* | float32 | n/a | [0 1] | | |
| 4 | *gypsum* | float32 | n/a | [0 1] | | |
| 5 | *hornblende* | float32 | n/a | [0 1] | | |
| 6 | *microcline* | float32 | n/a | [0 1] | | |
| 7 | *muscovite* | float32 | n/a | [0 1] | | |
| 8 | *quartz* | float32 | n/a | [0 1] | | |
| 9 | *blackbody* | float32 | n/a | [0 1] | | |
| 10 | *RMS* | float32 | n/a | n/a | Root Mean Square error across modeled spectra | |
| 11 | *B1 Residual Error* | float32 | n/a | n/a | Spectral residual for each specific band (B) | |
| 12 | *B2 Residual Error* | float32 | n/a | n/a | | |
| 13 | *B3 Residual Error* | float32 | n/a | n/a | | |
| 14 | *B4 Residual Error* | float32 | n/a | n/a | | |
| 15 | *B5 Residual Error* | float32 | n/a | n/a | | |
| 16 | *B6 Residual Error* | float32 | n/a | n/a | | |
| 17 | *WPS* | float32 | % | [0-100] | Whight Percent Silica | |

## 4. Examples of MASTER Level - 3 Surface Mineralogy (L3 SM) product

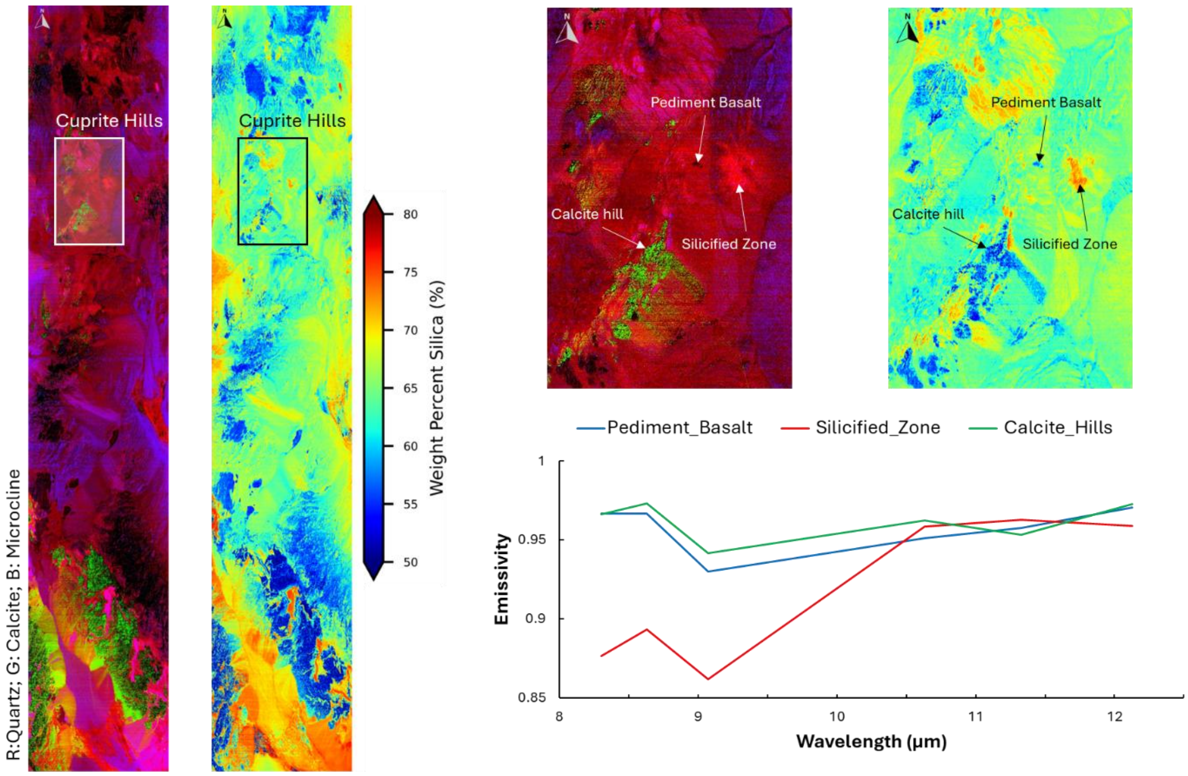


*Figure 1: Example of the MASTER Level3 SM product for flight line 2495000_05. The SM and WPS products over Cuprite and Death Valley are shown as follow: the SM product is displayed as an RBG false-color composite of Quartz, Calcite and Microcline, while the WPS is represented using a color scale ranging from blue (50%) to red (70%) to indicate the silica content as Weight Percent Silica. A plot of the emissivity for three key areas is also shown, highlighting the low emissivity of the pediment basalt area (as a blue line), the absorption feature near 11.3 µm (as a green line) characteristic of calcite in Calcite Hills and the deep Si-O absorption feature around 9 µm (as a red line) observed in the silicified area.*

Using the above representation, in Cuprite Hills area, three keys lithological units can be clearly distinguished. The silicified zone on the eastern hill, which appears red in both the WPS and the RGB false-color combination of the SM product – due to the deep Si-O absorption feature. The pediment basalt, which appears blue in the WPS and dark in the RGB false-color combination – due to its low emissivity. The calcite-rich hill, characterized by its low silica content, appears blue in the WPS and green in the RGB false-color composite image – due to the absorption feature near 11.3 µm.

Note that the displayed band combination is designed to enhance the contrast between silica-rich and carbonate materials, mainly due to the opposing absorption features at longer wavelengths. To highlight angelized alteration zones, however, different band combinations should be applied.

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