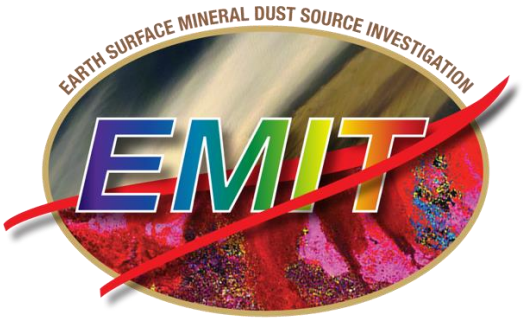

Earth Surface Mineral Dust Source Investigation (EMIT)

Level 2B Greenhouse Gas Data Product User Guide

Draft v01

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Jet Propulsion Laboratory
California Institute of Technology

Signature Page

Prepared by:

_____ _____
Philip Brodrick Date
EMIT SDS Algorithm Development Lead

_____ _____
Winston Olson-Duvall Date
EMIT SDS Software Systems Engineer

Approved by:

_____ _____
Sarah Lundeen Date
EMIT SDS Manager

Change Log

Date	Sections Changed	Reason for Change	Revision
08/30/2023	All	All	Initial Release

EPDM Electronic Signatures

Snapshot of signatures from EPDM will be added upon release

Contacts

Readers seeking additional information about this product may contact the following:

Phil Brodrick
philip.brodrick@jpl.nasa.gov

Andrew Thorpe
Andrew.k.thorpe@jpl.nasa.gov

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1 Introduction

1.1 Identification

This document describes information about the file structure and datasets provided in the EMIT Level 2B Greenhouse Gas data products. The algorithms and data content of the Level 2B CH4ENH and CH4PLM data products are described briefly in this guide, with the purpose of providing the user with sufficient information about the content and structure of the data files to enable the user to access and use the data, in addition to understanding the uncertainties involved in the products. More detail on the detection methods used are available in the L2B GHG ATBD (https://lpdaac.usgs.gov/documents/1696/EMIT_GHG_ATBD_V1.pdf).

1.2 Mission Overview

Mineral dust aerosols originate as soil particles lifted into the atmosphere by wind erosion. Mineral dust created by human activity makes a large contribution to the uncertainty of direct radiative forcing (RF) by anthropogenic aerosols (USGCRP and IPCC). Mineral dust is a prominent aerosol constituent around the globe. However, we have poor understanding of its direct radiative effect, partly due to uncertainties in the dust mineral composition. Dust radiative forcing is highly dependent on its mineral-specific absorption properties. The current range of iron oxide abundance in dust source models translates into a large range of values, even changing the sign of the forcing (-0.15 to 0.21 W/m2) predicted by Earth System Models (ESMs) (Li et al., 2020). The National Aeronautics and Space Administration (NASA) recently selected the Earth Mineral Dust Source Investigation (EMIT) to close this knowledge gap. EMIT was launched on July 14, 2022 to the International Space Station (ISS) to directly measure and map the soil mineral composition of critical dust-forming regions worldwide.

In addition to its primary objective described above, EMIT has demonstrated the capacity to characterize methane (CH_4) and carbon dioxide (CO_2) point source emissions by measuring gas absorption features in the shortwave infrared. This document breaks from the other mission Algorithm Theoretical Basis Documents (ATBDs), as the CH_4 and CO_2 products are not part of the standard series of interconnected science products. Readers should consult the L1B ATBD for the precursor products to what are used here.

The EMIT Project is part of the Earth Venture-Instrument (EV-I) Program directed by the Program Director of the NASA Earth Science Division (ESD). EMIT is comprised of a VSWIR Infrared Dyson imaging spectrometer adapted for installation on the International Space Station (ISS). EMIT measures radiance between 380 and 2500 nanometers, with an approximate 7 nm bandpass. Data are collected in a swath that is approximately 75 km wide at the equator, with an approximate ground sampling distance of 60 m.

1.3 Product Overview

Shortly after completing initial data validation, it became evident that EMIT was a particularly useful tool for mapping out greenhouse gases, including methane, carbon dioxide, and water vapor. This is consistent with previous findings from airborne data, but global nature, revisit frequency and wide swath of EMIT provided an unprecedented opportunity to investigate greenhouse gas

retrievals. Early prototypes of this data appeared on the VSWIR Imaging Spectroscopy Interface for Open Science (VISIONS; https://earth.jpl.nasa.gov/emit/data/data-portal/Greenhouse-Gases/), and based on high demand the EMIT GHG product suite was developed.

There are currently two greenhouse gas data products being produced by EMIT, the EMIT L2B Methane Enhancement Data product (EMIT L2B CH4 ENH) and the EMIT L2B Estimated Methane Plume Complexes (EMIT L2B CH4 PLM), with several additional products planned. Both of these products are provided as Cloud Optimized GeoTIFFs (COGs), with accompanying GeoJSON metadata.

More products, including mirrored carbon dioxide products, and emission rate estimates, are planed for the near future.

1.4 File Formats

1.4.1 Metadata Structure

EMIT operates from the ISS, orbiting Earth approximately 16 times in a 24-hour period. EMIT starts and stops data recording based on a surface coverage acquisition mask. The top-level metadata identifier for EMIT data is an orbit, representing a single rotation of the ISS around Earth. A period of continuous data acquisition within an orbit is called an orbit segment, where each orbit segment can cover up to thousands of kilometers down-track depending on the acquisition mask map. Each orbit segment is broken into scenes of 1280 down-track lines for convenience, though scenes may be seamlessly reassembled into orbit segments. To prevent a very small number of lines in any scene, the last scene can extend up to 2559 lines.

Because plume complexes are not constrained to a single scene, the CH4PLM product does not utilize scene or orbit numbers – instead, a unique, global plume complex identifier is utilized. The plume complex identifier does not monotonically increase nor should it be used to infer information about when a plume complex was observed or identified. In the case of CH4PLM, the timestamp used is the timestamp associated with the earliest scene that a plume intersects.

The EMIT Greenhouse Gas collections (EMITL2BCH4ENH and EMITL2BCH4PLM) contain a combination of COG, PNG, and GeoJSON files, as described in Table 1-1.

Table 1-1: EMIT Greenhouse Gas collection file list and naming convention

Collection: EMIT L2B Methane Enhancement Data – EMITL2BCH4ENH	
	Methane Enhancements: EMIT_L2B_CH4ENH_<VVV>_<YYYYMMDDTHHMMSS>_<OOOOO>_<SSS>.tif
	Browse: EMIT_L2B_CH4ENH_<VVV>_<YYYYMMDDTHHMMSS>_<OOOOO>_<SSS>.png
Collection: EMIT L2B Methane Plume Complexes – EMITL2BCH4PLM	
	Plume Complexes: EMIT_L2B_CH4PLM_<VVV>_<YYYYMMDDTHHMMSS>_<IIIIII>.tif
	Metadata and Uncertainty: EMIT_L2B_CH4PLM_<VVV>_<YYYYMMDDTHHMMSS>_<IIIIII>.json
	Browse: EMIT_L2B_CH4PLM_<VVV>_<YYYYMMDDTHHMMSS>_<IIIIII>.png

<VVV> gives the software version number, e.g., 001
<YYYYMMDDTHHMMSS> is a time stamp, e.g., 20220101T083015
<OOOOO> is the orbit identification number, e.g., 12345
<SSS> is the scene identification number, e.g., 007
<IIIIII> gives a unique global plume identifier for the plume complex, e.g. 000120

1.4.2 L2B GHG Data Products

The EMIT L2B Greenhouse Gas collections contain estimated greenhouse gas enhancements. Files are provided either as COGs, which are orthorectified (latitude/longitude, projected using WGS 84, EPSG:4326) using nearest neighbor resampling, consistent with geometric lookup tables provided in other EMIT products.

Table 1-1: EMIT L2B Data Products Summary

Earth Science Data Type	Product Level	Data Dimension	Spatial Resolution	Swath Width	Map Projection
Collection	*EMITL2BCH4ENH*				
Methane Enhancement Data	L2	x, y, 1	60 m*	72 km*	WGS-84, EPSG:4326
Collection	*EMITL2BCH4PLM*				
Methane Plume Complexes	L2	x, y, 1	60 m*	72 km*	WGS-84, EPSG:4326

* Nominal at equator

1.5 Product Availability

The EMIT L2B Greenhouse Gas products will be available at the NASA Land Processes Distributed Active Archive Center (LP DAAC, https://lpdaac.usgs.gov/) and through NASA Earthdata (https://earthdata.nasa.gov/).

2 Greenhouse Gas Products

The EMIT Level 2B Greenhouse Gas products are a series of products that can be used to identify and quantify point source emissions. The first step is an enhancement estimate, which is fundamentally based on an adaptive matched filter approach. This yields an estimate of GHG enhancement in parts per million meter (ppm m), a total column enhancement estimate. This is provided at the EMITL2BCH4ENH product for methane. Next, individual plumes are identified and vetted by multiple scientists, and high confidence plume complexes are provided for methane in the EMITL2BCH4PLM product. Both datasets are provided as cloud optimized GeoTIFFs (COGs), with some supporting metadata provided in the EMITL2BCH4PLM GeoJSON files.

2.1 Delivery Frequency

Recognizing the value of both high confidence and low latency, EMIT products look to strike a balance on delivery. Matched filter results are computed on the EMIT SDS on a daily basis, following the generation of L1B and L2A products. However, a manual review of each scene is required before plumes are identified. This can introduce additional latency from the time the time the initial processing is complete. In general, most scenes are available to the EMIT SDS within

a week of observation. Manual plume complex identification can introduce another week or so of latency, after which plumes are delivered. Once a plume complex is identified and confirmed by the requisite three scientists (see ATBD for details), the plume complex is sent to the LP DAAC as soon as operationally viable (usually within hours).

2.2 File Structure

Both L2BCH4ENH and L2BCH4PLM are provided as COGs, and uncertainty estimates are provided along with the CH4PLM product in the GeoJSON metadata. Products are single band and vary in size; L2BCH4ENH products follow EMIT scene sizes but are projected and so vary in size. L2BCH4PLM data depend on the size of an individual plume complex and vary substantially more. L2BCH4PLM data also include GeoJSON files, which include an outline of each plume complex along with other metadata. Each GeoTIFF includes a variety of metadata fields to specify additional parameters.

Appendix A: Acronyms

Term	Definition
ADC	Analog to Digital Converter
APID	Application Identifier
ASCII	American Standard Code for Information Interchange
BIL	Band Interleaved by Line
CCSDS	Consultative Committee for Space Data Systems
DAAC	Distributed Active Archive Center
DCID	Data Collection Identifier
DN	Digital Number
EMIT	Earth Mineral dust source InvesTigation
ENVI	Environment for Visualizing Images
ESDIS	Earth Science Data and Information System
ESM	Earth System Model
FPA	Focal Plane Array
FPGA	Field Programmable Gate Array
FPIE	Focal Plane Interface Electronics
FPIE-A	Focal Plane Interface Electronics - Analog
FSW	Flight Software
Gbps	Gigabits per second
GLT	Geometry Lookup Table
HOSC	Huntsville Operations and Support Center
ICD	Interface Control Document
IOS	Instrument Operations System
ISS	International Space Station
JPL	Jet Propulsion Laboratory
kHz	Kilohertz
L0	Level 0 (compressed, raw packets)
L1A	Level 1A (reconstructed, uncompressed data reassembled into scenes)
L1B	Level 1B (calibrated radiances with geolocation parameters)
L2A	Level 2A (atmospherically-corrected surface reflectance)
L2B	Level 2B (mineral feature depth maps)
L3	Level 3 (gridded global map of mineral composition and abundances)
L4	Level 4 (model runs of GISS ModelE2 and NCAR CESM)
LP DAAC	Land Processes Distributed Active Archive Center
LSB	Least Significant Bit
MSB	Most Significant Bit
NASA	National Aeronautics and Space Administration
NetCDF	Network Common Data Format
PGE	Product Generation Executable
PLRA	Program Level Requirements Appendix
ROIC	Readout Integrated Circuit
SDS	Science Data System
SIS	Software Interface Specification

SSDR	Solid State Data Recorder
UTC	Universal Time Coordinated