Product Guide

Data Definition & Specification

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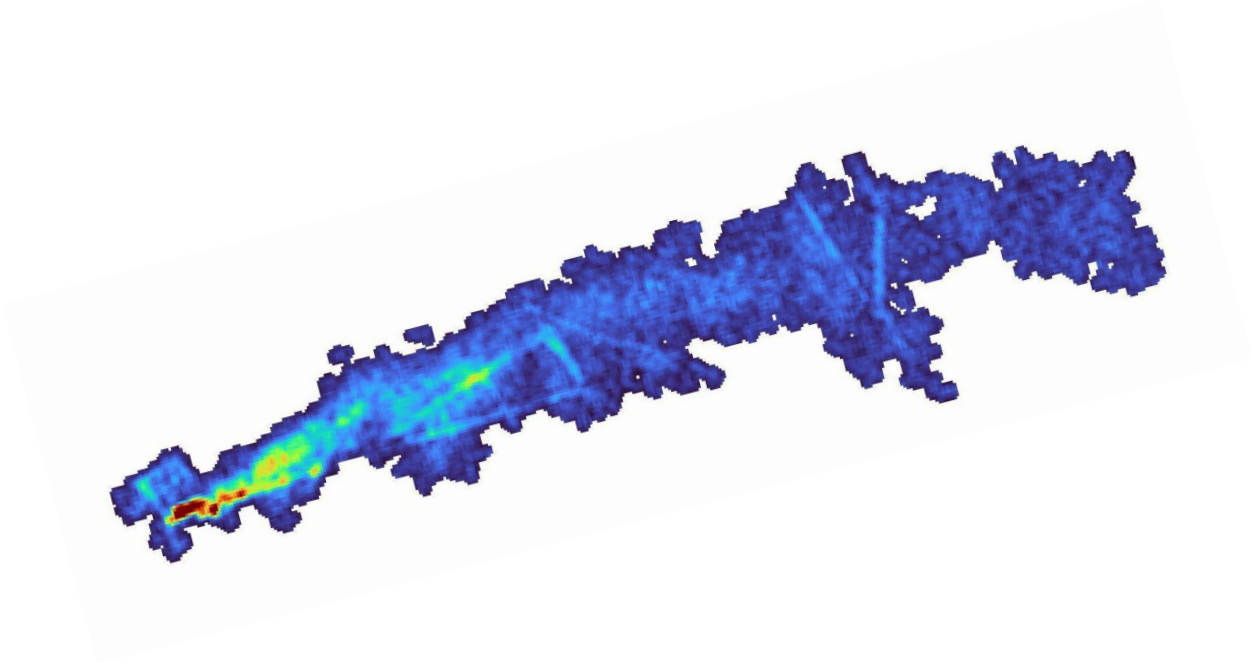

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Table of Contents

Table of Contents 2
Introduction 3
Purpose 3
Definitions and Acronyms 3
Sensor Information 5
Data Overview 5
Products Overview 6
Data Access 8
Product Details 10
Level 1 Products 10
L1B-calibrated radiance and masks 10
Level 2 Products 11
L2-scene outlines 11
L2A-simultaneous RGB imagery 12
L2B-atmospheric retrievals 12
L2C-plume detections 13
Level 3 Products 14
L3A-preliminary plume images 14
L3A-PHME: Potentially Harmful Methane Event 15
L3B-Fully processed plume images 16
Level 4 Products 17
L4A-plume emissions 17
L4B-source emissions 17
Level 5 Analytics and Data Fusion 18
L5: Analytics 18
Naming Conventions 19
Field names and definitions 20

For more information contact data@carbonmapper.org

Introduction

Carbon Mapper is a non-profit organization building a global observing system to track large-scale, human-caused methane and carbon dioxide emissions. Our efforts are supported by a unique coalition of private and public sector partners, including Planet, NASA Jet Propulsion Laboratory, the State of California, the University of Arizona, Arizona State University, and RMI (formerly known as the Rocky Mountain Institute). The breadth of this coalition provides the expertise and resources needed to deploy a science-driven, sustained, and operational decision support system that maximizes impact.

Carbon Mapper utilizes a combination of satellites and aircraft to provide daily to weekly observations of emissions from point sources, such as oil and gas facilities, solid waste, coal, and agricultural operations. This data is freely available to the public and serves as a valuable resource for governments, businesses, and organizations seeking to reduce emissions and combat climate change.

The Carbon Mapper open data platform plays a pivotal role in making this data accessible to all interested parties. With origins and initial development at NASA's Jet Propulsion Laboratory, this platform processes data from various satellite and airborne hyperspectral platforms, including Planet's Tanager constellation, which sits at the core of Carbon Mapper's goal to create a global observing system. Additionally, the platform integrates data from NASA's EMIT sensor, airborne sources such as NASA AVIRIS-NG, and the Global Airborne Observatory at Arizona State University.

In addition to methane, Carbon Mapper is also capable of tracking carbon dioxide emissions. The system has a CO_2 detection limit sufficient to track 90% of the world's coal power plant emitters, most refineries and large gas power plants.

The Carbon Mapper global observing system and open data platform are powerful tools for understanding and mitigating emissions. The data is freely accessible at https://data.carbonmapper.org for non-commercial research and development purposes.

Purpose

This document aims to provide an overview of the products and access mechanisms that make up the Carbon Mapper open data platform. A detailed description of each product is included below, along with uses, release latency, data format, and data access & storage. All products defined in this document are derived from calibrated, non-orthorectified radiances. More complete information on the retrieval algorithms underlying these products will be found in forthcoming Carbon Mapper Algorithm Theoretical Basis Documents (ATBDs).

Definitions and Acronyms

Definitions

Flux	A mass of methane per unit time, per unit area, independent of sources.
Emission rate (kg/hr)	A mass of methane per unit time for an individual source, a component of total flux.
Instantaneous emission estimate	The emissions rate calculated for a single plume at a specific moment. This value does not represent overall source emissions but rather the emission rate derived from a single plume observation.

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Plume	An excess mass or concentration of gas in the atmosphere emitted from a specific source. Plumes are the atmospheric manifestation of emission processes occurring across various economic sectors.
Plume ID	A unique identifier for each plume.
Source	A specific geographic location from which emissions originate. Point sources are a type of source that is associated with a large emission from a concentrated area represented by a specific latitude and longitude.
Source ID	A unique identifier for each source.
Plume List	A list of all plumes and associated metadata over a specific time period and region.
Source List	A list of all sources and associated metadata over a specific time period or region.
Persistence	The frequency at which a source emits methane or carbon dioxide, defined as the number of plumes detected divided by the total number of unobscured overpasses.
Null Detect	The absence of detection under optimal observing conditions, such as an unobstructed view of the emission source and a high likelihood of detection.
Source Emission Rate	A mean emission rate of all plumes attributed to a single source multiplied by persistence. A source emission rate is an overall rather than an instantaneous emission rate and can only apply to a source, not a plume.
Source Attribution	Attribution of on-the-ground infrastructure to individual plumes. May include information such as: • Sector (Oil & Gas, Solid Waste, Livestock, Coal Mining, Wastewater, etc.) • Equipment type (Compressor Station, Tank Battery, Flare, etc.) • Facility name • Operator/owner name

Acronyms

PHME	Potentially Harmful Methane Event: An experimental product defined as a methane emissions event whose resulting surface-level concentrations exceed at least one safety or health-based concentration threshold: • Proximity-only: plume origin is within 100 m of the nearest identifiable sensitive receptor (any potentially human-occupied building) which addresses smallest detectable plumes close to people, OR • Size and proximity: observed plume length exceeds 1000 meters AND overlaps nearest identifiable sensitive receptor – which indicates a reasonably high emission event and potential for surface mixing ratios exceeding a certain lower explosive limit (LEL) within proximity to people
IME	Integrated Mass Enhancement: The total kilograms of methane in a plume above the background concentration at the time of the image capture
MDL	Minimum Detection Limit: The lowest emission rate that a technology can detect given certain environmental conditions (e.g., wind speed, ground reflectivity) that has been validated with ground-truth data

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Sensor Information

Carbon Mapper products are derived from a range of hyperspectral sensors on satellites and airplanes, also known as imaging spectrometers. These sensors collect light at a wide range of wavelengths, allowing them to detect and quantify atmospheric gasses. By developing the capacity to ingest data from multiple sensors, Carbon Mapper can produce and release a large number of plumes over a wide range of sources and locations, regardless of the sensor used. This results in data fusion, a process that combines and normalizes data across sensors to create a more complete picture of human-caused greenhouse gas emissions over time. The table below summarizes the sensors used by Carbon Mapper.

Provider	Platform	Type	Approximate ground sampling distance (GSD)*	Spectral Bands	More Info
Planet Labs PBC	Tanager	Satellite	30-40m	400-2500 nm (~5nm spacing)	link
NASA-JPL	EMIT (Earth Surface Mineral Dust Source Investigation)	Satellite	50-60m	381–2493 nm (~7.5 nm spacing)	link
NASA-JPL	AVIRIS-NG (Airborne Visible/Infrared Imaging Spectrometer-Next Generation)	Airborne	3-8m	380-2510 nm (5nm spacing)	link
Arizona State University	Global Airborne Observatory	Airborne	3-5m	380-2510 nm (5nm spacing)	link

**Ground sampling distance (GSD) varies with changes in sensor altitude and off-nadir angle.*

Data Overview

Although methane and carbon dioxide emissions can originate from natural and human-made sources, the Carbon Mapper mission is focused primarily on identifying and monitoring human-made sources. Natural sources of methane include wetlands, rice paddies, wildfires, tundra ecosystems, and the decomposition of organic matter. Human-made sources encompass a wider range, including oil and gas production, agricultural activities, coal mining, solid waste landfills, and wastewater treatment facilities.

In addition to methane, Carbon Mapper can detect and measure the vast majority of CO_2 point source emissions from electricity generation (power plants), cement production, and other industrial processes.

Carbon Mapper organizes its emissions data into two primary data types: plumes and sources.

- **Plumes** are an excess mass or concentration of gas in the atmosphere emitted from a specific source. They are the atmospheric manifestation of emission processes occurring across various economic sectors.
- **Sources** are specific geographic locations from which emissions originate. Point sources are a type of source that is associated with a large emission from a concentrated area represented by a specific latitude and longitude.

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While plumes and sources reflect real-world features, their representations in the data may not always precisely match their actual infrastructure locations on the ground. This discrepancy stems from the varying accuracy of the underlying imagery and the detection methods used to pinpoint the exact plume origin.

Satellites and airborne sensors can detect plumes by measuring the amount of sunlight absorbed by gas in the atmosphere. By combining wind speed and direction with observed plume mass and capturing multiple observations over time to better understand the frequency of emissions, scientists can accurately estimate the emission rate of sources, not just plumes. A time-series-based aggregation approach like this results in a more complete global environmental impact of super-emitting infrastructure.

Both sources and plumes are derived from aircraft or satellite imagery in individual scenes or as longer continuous "strips." These geographic boundaries define the areas imaged by Earth observation satellites and aircraft. They play a crucial role in various Earth observation use cases by providing a spatial reference for data analysis and interpretation.

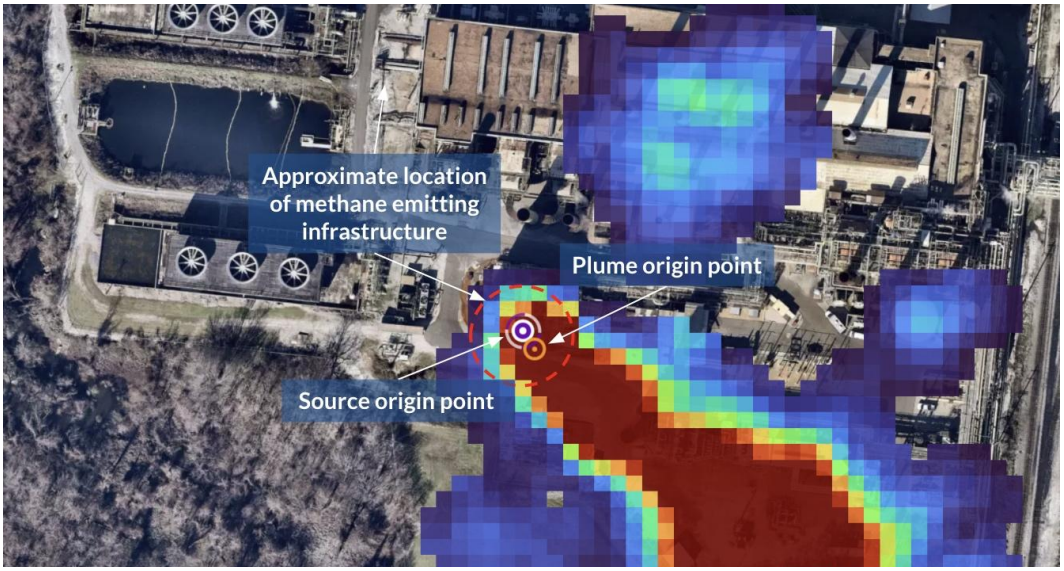

Figure 1: Example of a methane source at an oil and gas refinery and a plume attributed to that source.

Products Overview

Carbon Mapper products are designed to meet the needs of a wide range of users, from researchers and policymakers to industry and the public. They are organized into five levels, each representing a higher degree of processing, ranging from Level 1 raw radiance data to Level 5 advanced analytics. Carbon Mapper products are publicly available for non-commercial use through the Carbon Mapper data portal and APIs. They provide users with access to data, tools, and documentation to help them explore, analyze, and visualize human-caused point source emissions. Please visit our Terms of Use for information on data licensing.

Data Product	Description
Level 1B Calibrated radiance	Calibrated and compressed radiance images, including geolocation and observation geometry information, raster-level masks, and other metadata such as scene and valid pixel outlines, clouds, flares, specular, and dark masks. Generated in sensor and ortho space.

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	Carbon Mapper Internal Product Only
Level 2A Simultaneous RGB imagery	Orthorectified simultaneous RGB (Red, Green, Blue) imagery derived from radiance by correcting for atmospheric effects and processing to top-of-atmosphere reflectance.
Level 2B Atmospheric retrievals	Orthorectified whole scene methane and carbon dioxide retrievals derived directly from L1B radiance.
Level 2C Detections	Orthorectified whole scene salience maps, vector data, or tabular files of candidate plume detections.
Level 3A Preliminary plume images (quick looks)	Orthorectified preliminary maps of individual atmospheric CH_4 and CO_2 enhancements (segmented plumes). Otherwise known as "Quick Look" products with • plume image • acquisition date & UTC time • latitude and longitude of plume origin • initial IME, emission rate, and plume length estimates *Carbon Mapper Internal Product Only*
Level 3A-PHME	Potentially Harmful Methane Event (PHME) products are methane emission events that produce surface-level methane concentrations that exceed at least one safety or health threshold. L3A-PHMEs are experimental products that are identified and released on a best-effort basis.
Level 3B Fully processed plumes	Orthorectified final maps of individual atmospheric methane and carbon dioxide enhancements (segmented plumes) that pass quality control checks, with • plume image • sector attribution • acquisition date & UTC time • latitude and longitude of plume origin • IME estimate & uncertainty • plume length estimate & uncertainty

Level 4A
Plume emissions
	CH_4 and CO_2 plume emissions list including:
	
	• Tabular plume list with
	  • L3B attributes:
	  • plume image
	  • acquisition date & UTC time
	  • latitude and longitude of plume origin
	  • IME estimate & uncertainty
	  • plume length estimate & uncertainty
	  • quality flags
	  • sector attribution
	  • instantaneous emission rate & uncertainty
	  • wind speed, direction & uncertainty

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Level 4B Source emissions	Methane and CO_2 source emissions list including: • source Identifier • latitude and longitude of source origin • source persistence estimate & uncertainty • persistence-adjusted source emission rate & uncertainty • number of overpasses • number of positive detects • sector attribution
Level 5 Analytics	Analytics including aggregated source emission rates by sector, time, and geography. Future analytics may include cumulative distribution functions, emission variances by sector, fusion and normalization with non-methane or carbon dioxide datasets (e.g., infrastructure, socioeconomic, etc.), histograms, time series, and regional/sectoral up-scaling.

Data Access

All Carbon Mapper data products are publicly available through three channels:

- **Carbon Mapper Data Portal**: This is a web-based platform where users can view and download Carbon Mapper data products and register for advanced functionality such as API access, saved searches, collection notifications, and more.
- **Carbon Mapper Data API**: This developer-friendly API provides programmatic access to Carbon Mapper data products through various endpoints such as methane and CO_2 plume and source data..
- **Carbon Mapper STAC API**: This is an API that provides access to Carbon Mapper data products in a standardized format called SpatioTemporal Asset Catalog (STAC). STAC is a standard format for geospatial data that makes it easy to find, access, and use Carbon Mapper data products.

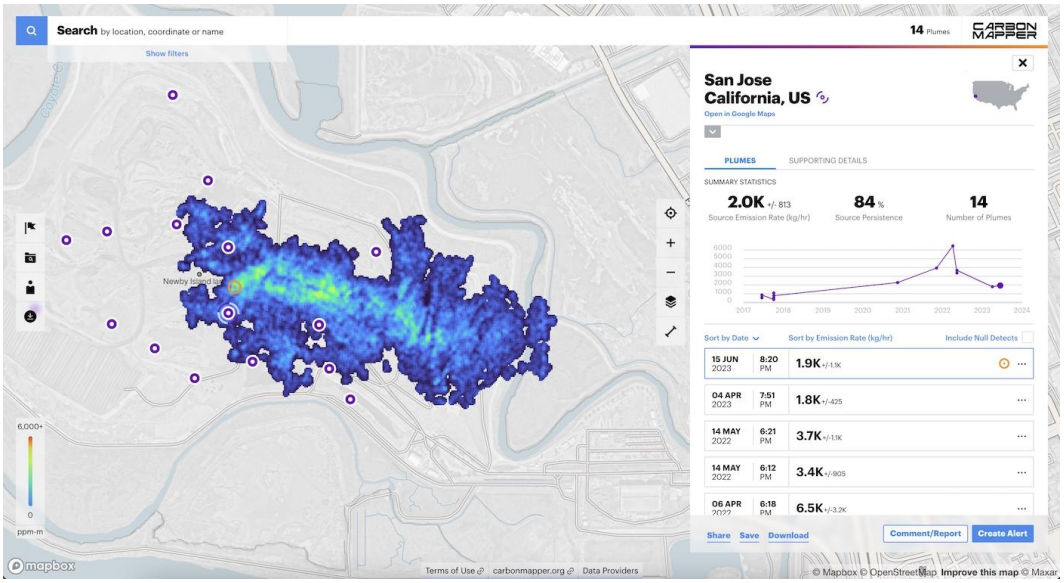

Figure 2: Data portal showing plumes over time at a single source at the Newby Island Landfill, Milpitas, CA

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Python


```
{
  "bbox_count": 0,
  "total_count": 0,
  "limit": 0,
  "offset": 0,
  "items": [],
  "nearby_items": [
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          "string"
        ],
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      "rgb_png": "string",
      "plume_bounds": [
        0
      ]
    }
  ]
}
```


Figure 3: Example response from the Plumes Annotated endpoint in the Carbon Mapper Data API

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Product Details

Level 1 Products

L1B-calibrated radiance and masks

Definition:

Carbon Mapper ingests raw radiance from various providers, calibrates and compresses it, and then utilizes the resulting cloud-optimized data to create a range of derived downstream products. These products include full-strip raster masks and additional metadata, as follows:

- Scene/valid pixel outlines
- Cloud masks
- Flare or artifact masks
- Specular and dark masks

Radiance is compressed and generated in sensor and ortho space.

Data Structure:

L1B data products are stored as orthorectified raster images in compressed cloud-optimized formats.

Data Availability:

Carbon Mapper generates L1B products primarily to derive downstream products, which are not released to the general public. Carbon Mapper makes available exemplar radiance products for research purposes, whereas specific radiance products can be directly obtained from their respective data providers.

Figure 4. Rendering of the Tanager-1 satellite, a primary radiance source for Carbon Mapper products.

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Level 2 Products

L2-scene outlines

Definition:

L2 scene outline products are the geographic boundaries, or “footprints” of areas imaged by Carbon Mapper satellites and aircraft. These outlines may also be called "strips" or consist of individual scenes that make up strips. Scene outlines are helpful for determining where Carbon Mapper data is collected, the quality of that data, and verifying when methane or carbon dioxide sources are imaged, but no detection has been observed.

In optimal observing conditions, such as an unobstructed view of the emission source and a high likelihood of detection, the absence of detection is termed a "null detect." In the realm of emissions remote sensing, a null detect signifies that an emission detection algorithm has not identified any evidence of methane emissions at a specific location. These null detects imply that the source is not emitting methane above the sensor's minimum detection limit.

Carbon Mapper considers a scene to be a good candidate for a null detect status for an emission source if the scene contains less than 25% cloud cover and intersects any of the plume origin points estimated for the source.

Data Structure:

Vector GIS data including but not limited to the GeoJSON format

Data Availability:

With some exceptions, L2 scene outlines are released publicly along with other Carbon Mapper products 30 days after acquisition.

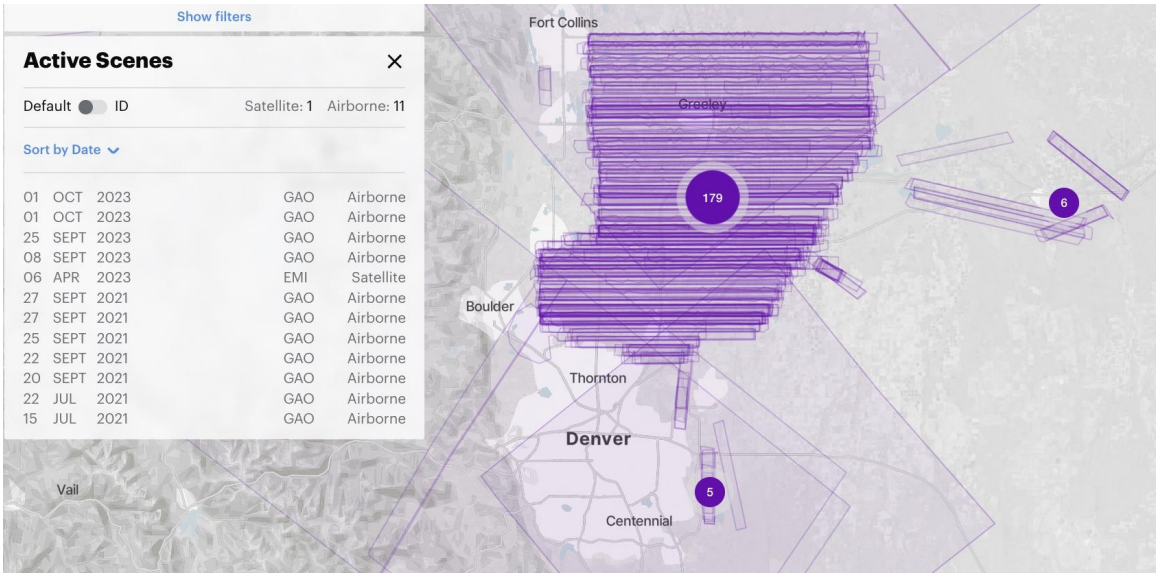

Figure 5. Scene outlines shown in the Carbon Mapper data portal with a list of active scenes selected for a particular emission source south of Greeley, CO.

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L2A-simultaneous RGB imagery

Definition:

L2A products are three-band, natural color images of the Earth's surface generated from raw satellite radiance. This process involves correcting for atmospheric effects, geometric distortions, and terrain variations to produce accurate and visually appealing representations of the Earth. “RGB” stands for the Red, Green, and Blue bands that comprise the natural color imagery.

Data Structure:

L2A data products are stored as orthorectified raster images in compressed cloud-optimized formats.

Data Availability:

L2A products are released publicly alongside other Carbon Mapper products 30 days after acquisition.

Figure 6. Level 2A simultaneous RGB imagery derived from airborne data underlying a methane source.

L2B-atmospheric retrievals

Definition:

L2B products consist of orthorectified full-strip atmospheric retrieval images derived from L1B radiance images. L2B products for methane and carbon dioxide are mixing ratios (i.e., concentrations) estimated for each pixel using a column-wise matched filter algorithm. The matched filter is a fast-running, statistical-based retrieval algorithm validated across multiple airborne controlled releases and independent aircraft mass-balance surveys.

Different L2B matched filter algorithms are best suited for unique observing environments. Among these, CM has deployed and tested multiple model versions across airborne field campaigns:

- Unimodal (Most validated with airborne controlled releases): Classical column-wise matched filter as described initially.
    - ch4mfa: methane (CH_4) dynamic absorption spectrum
    - co2mfa: carbon dioxide (CO_2) dynamic absorption spectrum

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- Multimodal (potentially superior for suppressing systematic artifacts, e.g., flaring): Column-wise matched filter with a clustering of pixels based on radiance values.
    - ch4mfm: methane (CH_4) multimodal
    - ch4mfma: methane (CH_4) multimodal, dynamic absorption spectrum
    - co2mfma: carbon dioxide (CO_2) multimodal, dynamic absorption spectrum

The units for L2B products are typically parts per million per meter (ppm-m). L2B products also include other full-strip images derived directly from L1B radiances; these products may include, but are not limited to flare retrievals and confuser retrievals that may be used for quality improvements.

These products are made from raw L1B data and corrected for geometric distortions so they can be used as the primary input for the plume detection and quality control process.

Data Structure:

L2B data products are stored as orthorectified raster images in compressed cloud-optimized formats.

Data Access:

L2B products are released publicly along with other Carbon Mapper products 30 days after acquisition.

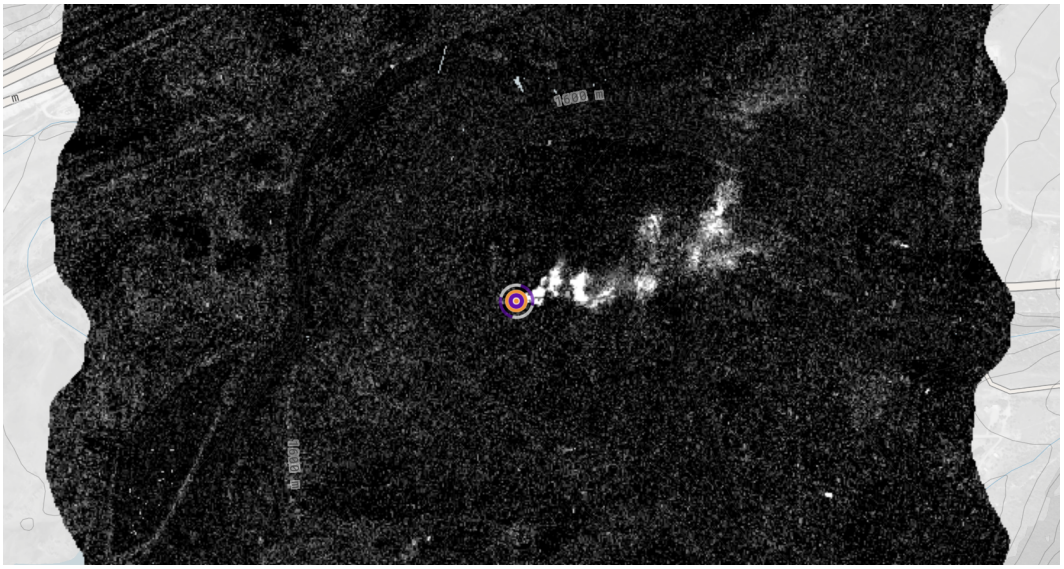

Figure 7. Level 2B methane atmospheric retrieval derived from airborne data underlying a methane source.

L2C-plume detections

Definition:

Vector data, tabular files, or orthorectified whole scene salience maps of possible plume origin locations. Level 2C (L2C) plume detections are generated from L2B atmospheric retrievals by trained analysts using quality assurance and quality control (QA/QC) processes. The analysts leverage whole scene salience maps generated by Convolutional Neural Networks (CNNs) to highlight the essential features in imagery where methane or carbon dioxide emissions are present.

Data Structure:

Tabular and associated raster data (e.g., CSV, GeoTIFF, PNG, GeoJSON)

Data Availability:

L2C products are released publicly along with other Carbon Mapper products 30 days after acquisition.

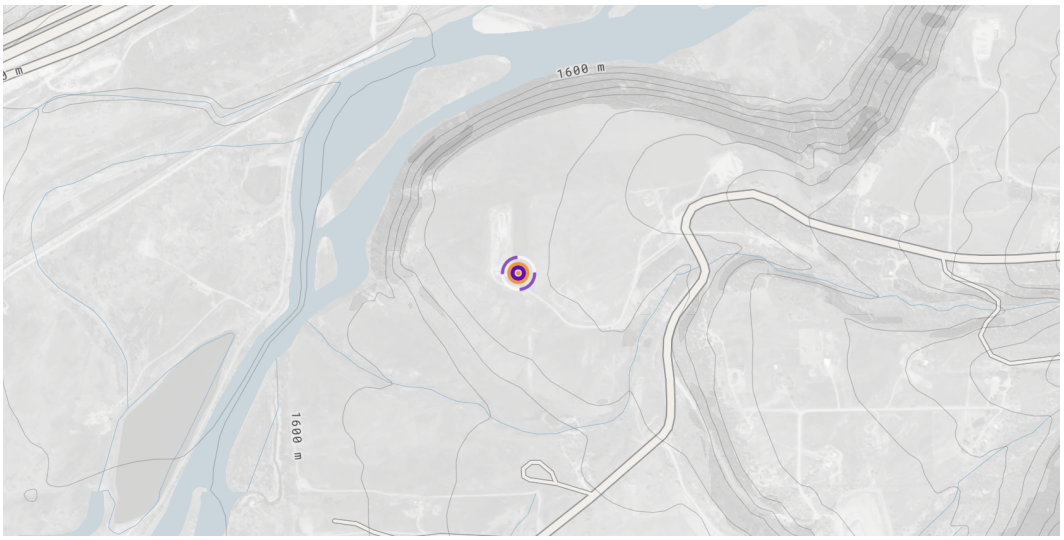

Figure 8. Level 2C plume detection and methane source origin point.

Level 3 Products

L3A-preliminary plume images

Definition:

L3A products are preliminary methane and carbon dioxide plume images that automated or manual processes have identified. They are intended for quick plume size and shape assessment and are unsuitable for final emissions estimates. Each plume includes the following information: acquisition date and time, latitude and longitude of plume origin, initial methane emission estimate, initial emission rate, initial quality flags, and plume length estimate. Carbon Mapper uses L3A products to identify Potentially Harmful Methane Events (PHME) and are only released as part of PHME products.

Latency:

Minimum production latency: ≤ 72 hours from acquisition

Data Structure:

Tabular and associated raster data (e.g., CSV, GeoTIFF, PNG, GeoJSON)

Data Access:

L3A products are not publicly available except in two cases: 1) Potentially Harmful Methane Event (PHME) products, 2) commercial quick look tasking products from Planet.

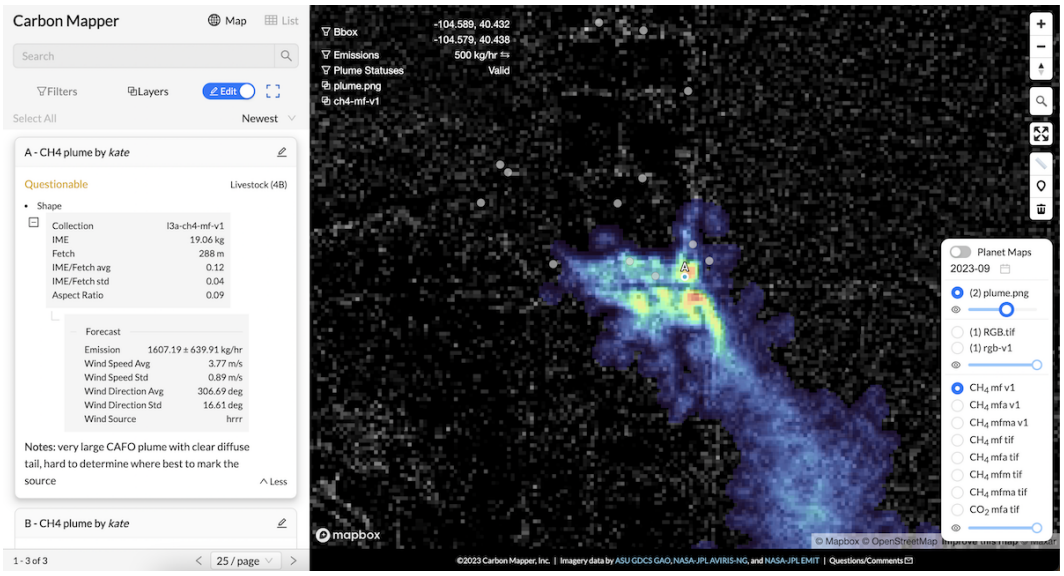

Figure 9. Quality assessment tools for final review of Level 3A methane plume images.

L3A-PHME: Potentially Harmful Methane Event

Definition:

Potentially Harmful Methane Event (PHME) products are methane emission events that produce surface-level methane concentrations that exceed at least one safety or health threshold. L3A-PHMEs are experimental products that will be determined on a best-effort basis. PHME status is activated if plumes meet either of the following criteria. These rules are subject to change and additional consideration by Carbon Mapper analysts:

- Proximity-only: plume origin is within 100 m of the nearest identifiable sensitive receptor (any potentially human-occupied building such as homes, commercial/industrial buildings, schools, hospitals, etc.) which addresses smallest detectable plumes close to people, OR
- Size and proximity: observed plume length exceeds 1000 meters AND overlaps nearest identifiable sensitive receptor – which indicates a fairly high emission event and potential for surface mixing ratios exceeding the LEL within proximity to people

PHME products consist of L3A-preliminary plume image products, defined above.

Latency:

Minimum production latency: ≤ 72 hours from acquisition

Data Structure:

Tabular and associated raster data (e.g., CSV, GeoTIFF, PNG, GeoJSON)

Data Availability:

This is an experimental product. Best efforts will be made to determine PHME status and release associated L3A products within 72 hours after acquisition.

For more information contact data@carbonmapper.org

L3B-Fully processed plume images

Definition:

L3B products are georeferenced plume images of segmented atmospheric methane and carbon dioxide enhancements assessed for quality. Each plume image is associated with the following metadata: acquisition date/time, latitude and longitude of plume origin, IME estimate with uncertainty, emission rate with uncertainty, plume length with uncertainty, updated quality flags, and any additional refinement of plume origin. Sector attribution is determined from the following IPCC-defined sector categories.

- Oil & Gas (1B2)
- Solid Waste (6A)
- Waste Water (6B)
- Livestock (4B)
- Coal Mining (1B1a)
- Electricity Generation (1A1)
- Other

When more granular GIS layers are available, additional attribution to the sub-sector, equipment type, or the operator level may be possible. When insufficient GIS information exists for source attribution, tasking of current satellite imagery may be initiated.

Quality flags may include but are not limited to

Scene level quality attributes

- Image artifacts [column, glint, flare, contrast, other]
- Low signal-to-noise [N(default)/Y]
- Atmospheric artifacts [clouds, smoke, haze, other]
- Cloud cover fraction [0, 25, 50, 75, 100] or [0-1]

Plume quality attributes

- Overall rating (Good, Questionable, or Bad)
- plume shape (Y/N)
- artifacts intersect plume (Y/N)
- flare (Y/N)
- high background enhancement (Y/N)
- PHME candidate (Y/N)

For a detailed description of Carbon Mapper's quality flag process, please refer to the Carbon Mapper Quality Control Description Document.

The L3B product may also undergo alternative retrieval processing using methods such as IMAP-DOAS, Optimal Estimation, etc.). If there is insufficient source data, manual identification, and satellite tasking may require additional time to finalize sector attribution. All data from L3B products are included in all subsequent downstream products.

Data Structure:

Tabular and associated raster data (e.g., CSV, GeoTIFF, PNG, GeoJSON)

Data Access:

L3B products are released publicly along with other Carbon Mapper products 30 days after acquisition.

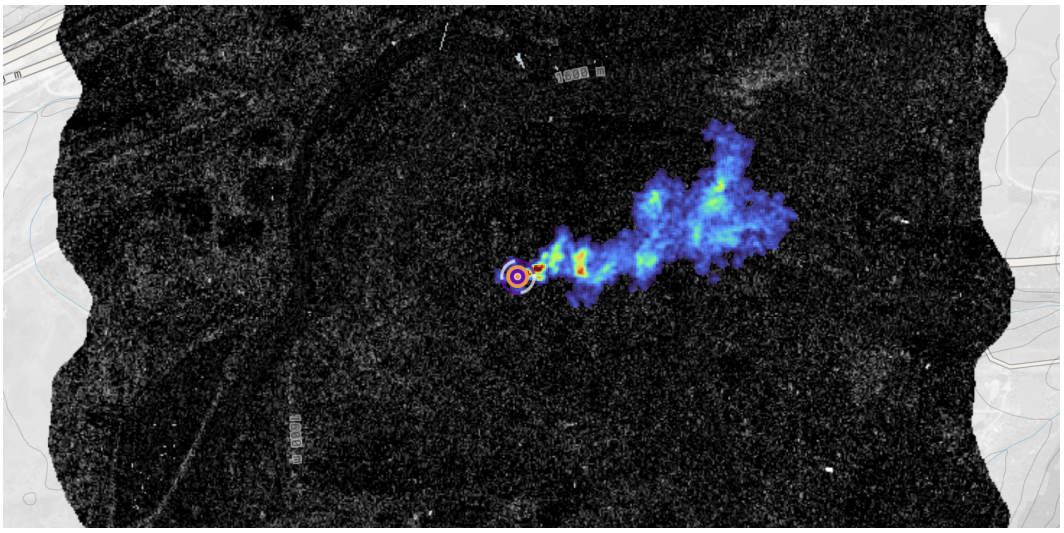

Figure 10. Level 3B final plume image arising from a methane source.

Level 4 Products

L4A-plume emissions

Definition:

L4A plume lists are tabular datasets that consist of plume level instantaneous emissions estimates and uncertainties, wind speed, direction and uncertainties, and all L3B attributes (quality flags, sector attribution, etc.). All L4A products are derived from L3B products and current conditions or reanalysis weather data.

Data Structure:

Tabular and associated raster data (e.g., CSV, GeoTIFF, PNG, GeoJSON)

Data Availability:

L4A products are released publicly along with other Carbon Mapper products 30 days after acquisition..

L4B-source emissions

L4B source lists are tabular datasets that consist of an aggregation of plumes mapped to discrete emission sources. Attributes include source identifier, latitude and longitude of source origin and uncertainty, sector attribution, number of overpasses, positive plume detections, persistence estimates, persistence-adjusted average emission rate, and uncertainties. All L4B products are derived from L3B products and current conditions or reanalysis weather data.

Data Structure:

Tabular and associated raster data (e.g., CSV, GeoTIFF, PNG, GeoJSON)

Data Availability:

L4B products are released publicly along with other Carbon Mapper products 30 days after acquisition.

Level 5 Analytics and Data Fusion

L5: Analytics

Definition:

Level 5 products are on-demand or bespoke analytics, including histograms, time series, regional/sectoral up-scaling, and fusion and normalization with non-CH_4/CO_2 datasets (e.g., infrastructure, socioeconomic, etc). An example is Aggregated Source Emission Rate: the sum of all source emission rates within a field of view or AOI.

Data Structure:

Web application analytics, API endpoints

Data Availability:

All analytics are generated dynamically and are not stored permanently.

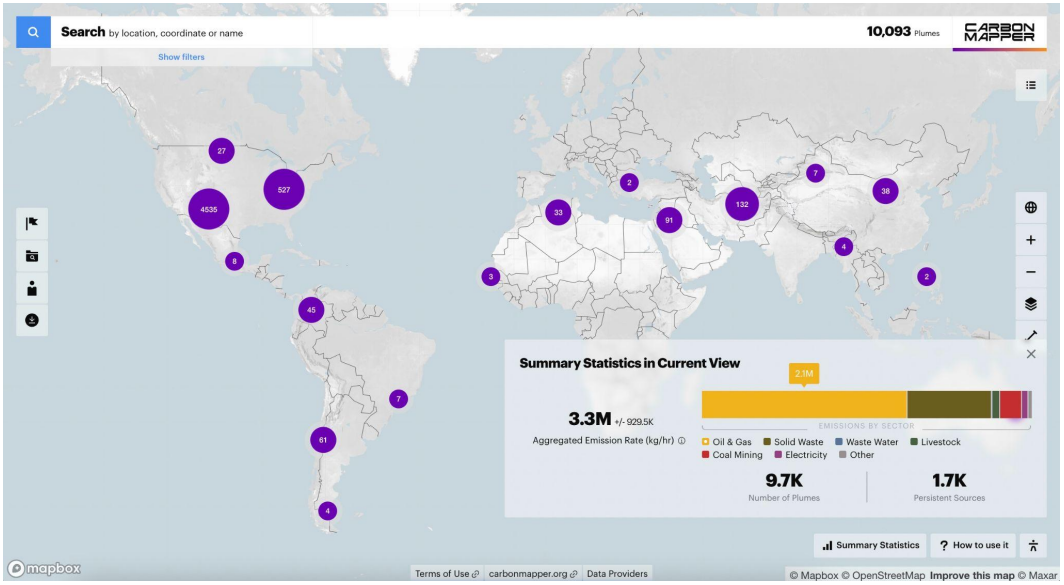

Figure 11. Example level 5 analytic summarizing point source emissions totals across broad geographies.

For more information contact data@carbonmapper.org

Naming Conventions

Carbon Mapper Level 1, Level 2, and Level 3 data products adhere to the following naming conventions:

Planet Tanager L1B:
20180604_190008_00_4902_0001_basic_radiance.h5
Resulting L1-L2b item id:
tan20180604t190008p0049020001
Resulting L2c-L4 item id:
tan20180604t190008p0049020001-A

EMIT L1B:
EMIT_L1B_RAD_001_20230824T175349_2323612_024
Resulting L1-L2b item id:
emi20230824t175349p12024
Resulting L2c-L4 item id:
emi20230824t175349p12024-A

Airborne Visible/Infrared Imaging Spectrometer-Next Generation (ANG) L1B:
ang20230121t192729_rdn_v2aa3_clip
Resulting L1-L2b item id:
ang20230121t192729
Resulting L2c-L4 item id:
ang20230121t192729-A

Global Airborne Observatory (GAO) L1B:
GAO20230614t170959p0000_rad
Resulting L1-L2b item id:
GAO20230614t170959p0000
Resulting L2c-L4 item id:
GAO20230614t170959p0000-A

Components of item id = {platform}{YYYYMMDD}{HHMMSS}-{part}
Type: Text, unique primary key
Description: unique identifier for each plume. The format is {platform}{YYYYMMDD}{HHMMSS}-{part}, where the first three characters represent the platform (e.g., GAO = Global Airborne Observatory), and the following fourteen characters represent the date and time of acquisition in ISO 8601 UTC format. The part suffix (e.g., "p0000-A") retains key info from the original radiance filename and identifies multiple plumes captured in the same image in the order they were detected.

Field names and definitions

Plume list fields

Name	Data Type	Description	Access
uuid	UUID, unique primary key	Universally unique object identifier, randomly generated using UUIDv4.	public (API only)
plume_id	Text, unique	Unique identifier for each plume. The format is {platform}{YYYYMMDD}{HHMMSS}-{part}, where the first three characters represent the platform (e.g., GAO = Global Airborne Observatory), and the following fourteen characters represent the date and time of acquisition in ISO 8601 UTC format. The part suffix (e.g., "p0000-A") retains key info from the original radiance filename and identifies multiple plumes captured in the same image in the order they were detected.	public
plume_latitude	decimal degree	Latitude estimate of plume origin	public
plume_longitude	decimal degree	Longitude estimate of plume origin	public
datetime	UTC timestamp in ISO 8601 format	Date and time of the acquisition in Coordinated Universal Time (UTC)	public
ipcc_sector	text, categorial identifier	IPCC emissions sector, if available (e.g., “Oil & Gas (1B2)") Reference: https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ri.pdf	public
gas	text, categorial identifier	The gas molecule detected during imaging operations	public
cmf_type	text, categorial identifier	Statistical based column-wise atmospheric retrieval algorithm used to threshold methane or carbon dioxide plumes from background concentrations	public
plume_bounds	decimal degrees	The geographic bounds encompassing a plume image	public
instrument	text	Three character abbreviation for sensor (e.g., GAO, ang (AVIRIS-NG), emi (), tng (Tanager), ssc (SkySat)	public
published_at	UTC timestamp in ISO 8601 format	Date and time the observation was pubished in Coordinated Universal Time (UTC)	
ime	float	The total kilograms (kg) of methane in a plume above the background concentration at the time of image capture	public
emission_auto	numerical, kg/hr	Quantified emission rate of a plume, estimated using the Integrated Methane Enhancement method (Duren et al., 2019 - "California's Methane Super-Emitters", Nature)	public

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emission_uncertainty_auto	numerical, ± kg/hr range	The uncertainty in an emission rate, derived from uncertainty in IME and wind speed	public
wind_speed_avg_auto	float	Mean wind speed m/s	public
wind_speed_std_auto	float	Standard deviation wind speed m/s	public
wind_direction_avg_auto	float	Wind direction (degrees)	public
wind_direction_std_auto	float	Wind direction standard deviation (degrees)	public
wind_source_auto	string	Wind source from reanalysis (e.g., Openmeteo, HRRR, ERA5)	public
platform	text	The unique name of the specific platform the instrument is attached to.	public
provider	Text	short description of data provider name	public
plume_tif	AWS signed URL	A time-limited, cryptographically signed URL that provides access to a protected resource. In this case, a GeoTIFF of the delineated plume.	public
plume_png	AWS signed URL	A time-limited, cryptographically signed URL that provides access to a protected resource. In this case, a PNG of the delineated plume.	public

Source list fields

Name	Data Type	Description
id	Text, unique primary key	Unique identifier for the source of a plume Format: gas_sector_cluster-distance_longitude_latitude
source_name	Text	Format: gas_sector_cluster-distance_longitude_latitude
source_lat	Decimal Degree	Latitude estimate of source origin (embedded in GeoJSON)
source_lon	Decimal Degree	Longitude estimate of source origin (embedded in GeoJSON)
cluster_id	Numerical, count	Numerical id for each source cluster
gas	Text, categorical	CH4 or CO2
sector	Text, categorical	IPCC emissions sector code (e.g. “1B2” for Oil & Gas)
plume_count	Numerical, count	Number of plumes attributed to a source
plume_ids	Text	Comma separated list of plume ids attributed to a source
emission_auto (source emission rate)	Numerical, kg/hr	Quantified emission rate calculated using the mean of all emissions attributed to a source weighted by persistence
emission_auto_uncertianty (source emission rate uncertainty)	Numerical, ± kg/hr range	Uncertainty in emission rate, derived from uncertainty in IME and wind speed. This combines all plume uncertainty attributed to the source weighted by persistence.
published_at_max	date	The latest published date for a source
published_at_min	date	The earliest publish date for a source

timestamp_max	date	The latest acquired date for a source
timestamp_min	date	The earliest acquired date for a source
date_count	Numerical, count	Number of observation days over a source
persistence	Numerical, ratio	Frequency of detection (number of plume detection days divided by the number of observation days)

Sector attribution codes

Name	Type	Options
Sector (short description) *required	String (single selection)	• Oil & Gas • Solid Waste • Waste Water • Livestock • Coal Mining • Electricity Generation • Other

Sector (database code) *required	String (single selection)	• Following categories from IPCC:
		• 1A1a Public Electricity
		  ○ CO_2 from coal and gas power plants
		• 1A1b Petroleum Refining
		  ○ CO_2/CH_4 from refineries
		• 1A2 Manufacturing Industries and Construction
		  ○ Includes petrochemical, and steel
		• 1B1 a Coal Mining
		  ○ CH_4 from coal mines and mining activities
		• 1B2 Oil and Natural Gas
		• 4A Enteric Fermentation
		• 4B Manure Management
		• 6A Solid Waste Disposal On Land
		• 6B Waste Water Handling
		• Other

Sub-Sector (not currently in use)	String (single selection)	• 1A1a Coal Power Plant • 1A1a Gas Power Plant • 1A2a Iron and Steel • 1A2c Chemicals • 1A2f Other (e.g., cement) • 1B1a Coal Mining - Mining • 1B1a Coal Mining - Mining activities (e.g., vents) • 1B1a Coal Mining - post-mining activities (e.g., coal crushers) • 1B2a Oil Exploration • 1B2a Oil Production • 1B2a Oil Transport • 1B2a Oil Storage • 1B2a Oil Distribution • 1B2a Oil Other • 1B2b Natural Gas Production • 1B2b Natural Gas Processing • 1B2b Natural Gas Transmission/Distribution • 1B2b Natural Gas Residential and Commercial • 1B2c Venting and Flaring Oil • 1B2c Venting and Flaring Oil • 1B2c Venting and Flaring Combined • 4A1a Dairy Cattle

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		• 4A1b Non-Dairy Cattle • 4A8 Swine • 4A9 Poultry • 6A1 Managed Waste Disposal on Land • 6A2 Unmanaged Waste Disposal Sites • 6B1 Industrial Wastewater • 6B2 Domestic and Commercial Wastewater
Equipment Type (not currently in use)	String (single selection)	• Power plant exhaust stack • Cogen plant • Hydrogen plant • Surface coal mine • Underground coal mine vent • Coal crusher • O&G separator • O&G condensate tank • O&G stock tank • O&G well head • O&G waste pit • O&G frac pond • O&G waste water • O&G offshore platform • Gathering pipeline • Transmission pipeline • Distribution pipeline • Compressor station • Compressor vent • Compressor turbine • Bypass stack • Metering station • Filter/scrubber • Flare stack • Cold vent • Gas processing plant • LNG export terminal • LNG import terminal • LNG storage tank • CNG storage tank • Livestock manure pond • Livestock manure digester • Livestock - other • MSW landfill • Dumpsite • Waste digester • Composting facility • Wastewater digester • Wastewater plant • Tanker ship • Natural methane source

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