CARBON LIMITS

Satellite Data:
Use Cases in Methane Emission Management

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Satellite-based methane observations are increasingly used to support methane emission management, yet their practical application across regulatory, operational, and inventory contexts remains uneven. This report presents four use cases illustrating how satellite data can support methane emission management: **identifying emission sources, advancing methane mitigation, improving national methane inventories, and informing regulation**. Drawing on publicly available satellite datasets and real-world implementation experience, the report examines how satellite detections can be interpreted, combined with operational data and ground-based verification, and embedded into structured workflows involving regulators and operators. The analysis highlights both the strengths and limitations of satellite observations, including detection thresholds, temporal coverage, and uncertainty in emission estimates, and emphasizes the importance of integrating satellite data as complementary evidence rather than a standalone solution. Together, the use cases demonstrate how systematic use of satellite data can improve transparency, prioritization, and decision-making across the methane management cycle, while supporting more data-driven and adaptive regulatory approaches.

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Carbon Limits works with public authorities, private companies, finance institutions and non-governmental organizations to reduce greenhouse gas emissions from a range of sectors. Our team supports clients in the identification, development, and financing of projects that mitigate climate change and generate economic value, in addition to providing advice on the design and implementation of climate and energy policies and regulations.

Disclaimer

This report is intended to provide general guidance on the use of publicly available satellite data for methane emission identification, mitigation support, inventory improvement, and regulatory processes. The examples, workflows, and use cases presented are illustrative and are not intended to prescribe specific regulatory actions or replace existing national laws, regulations, or reporting requirements.

This report reflects information available at the time of publication and is intended to support understanding and discussion. Decisions taken based on this information remain the responsibility of the user.

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Executive Summary

Satellite-based methane observations are increasingly shaping how methane emissions are detected, understood, and addressed. This report explores how publicly available satellite data can be used in practice. It presents four use cases that show how satellite data can help regulators and operators move from detection to action, while recognising the technical and practical limits of satellite observations.

Use Case 1: Identifiying Methane Emission Sources

Satellite data offers a strong starting point for identifying large methane emissions that might otherwise go unnoticed. The report shows how source identification can be approached as a two-step process: desktop source attribution using satellite imagery and operational data, followed by targeted ground verification where possible. While satellite detections alone cannot confirm emission sources or their root causes, repeated observations and contextual analysis help narrow down the most likely sources and guide efficient on-the-ground investigations.

Use Case 2: Advancing Methane Mitigation

Once emissions are identified, satellite data can support mitigation by helping prioritise actions based on emission size and persistence. The report illustrates how satellite detections can inform the choice of mitigation pathways, while emphasising that effective mitigation depends on understanding what is driving the emissions. Responses may range from relatively simple repairs or operational adjustments to more complex equipment upgrades or process changes, depending on the source and underlying cause. Follow-up satellite observations, combined with ground-based checks where appropriate, provide added confidence that mitigation measures have been effective over time.

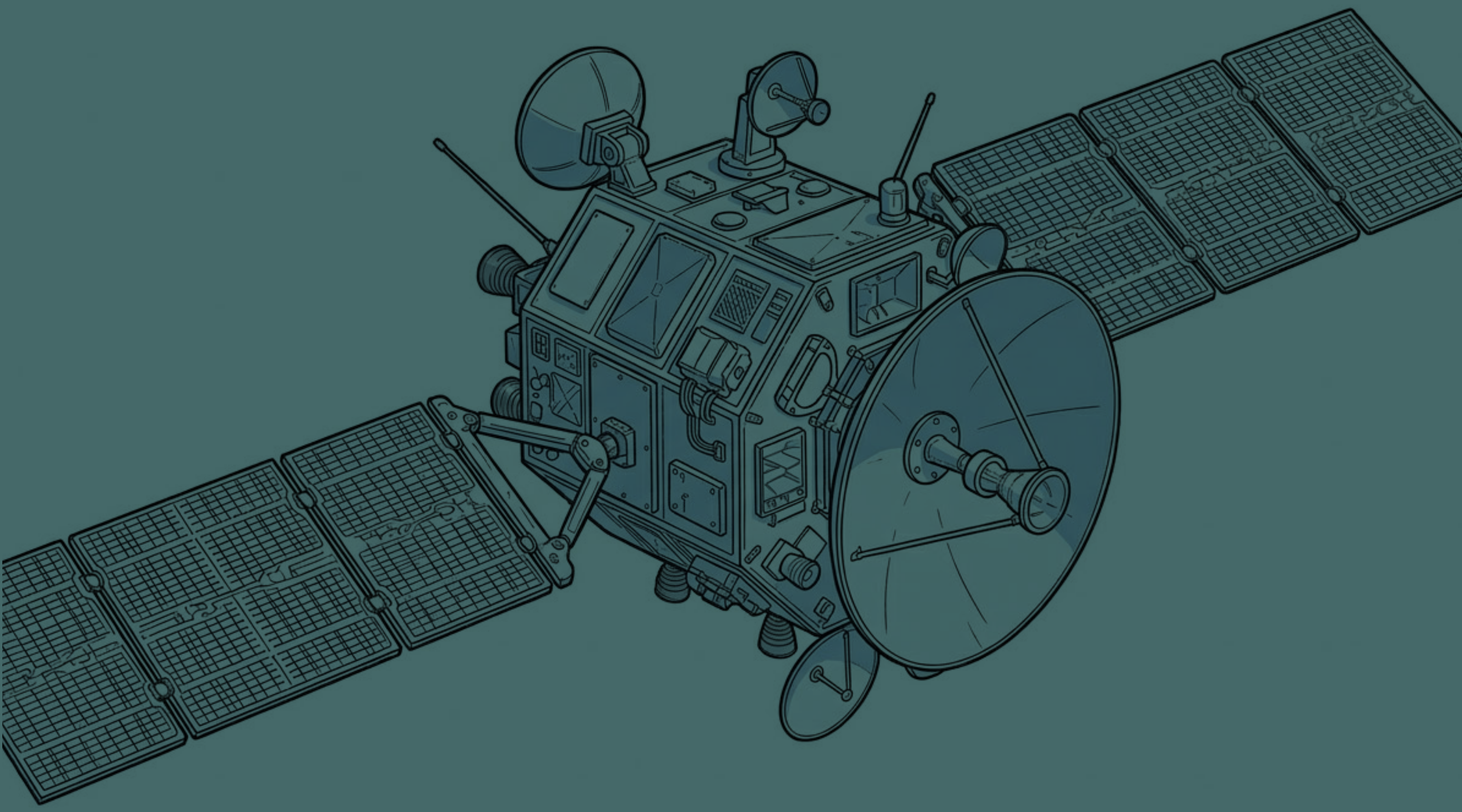
Use Case 3: Improving National Methane Inventories

Satellite observations provide an independent atmospheric perspective that can strengthen national methane inventories. The report shows how satellite data can support inventory quality assurance and quality control by highlighting systematic differences between reported bottom-up estimates and observed atmospheric emissions. Area-scale satellite data can point to regions or sectors where emissions may be under- or over-estimated, while point-source observations help reveal large emission events that are often missed by emission factor-based approaches. Used within the IPCC framework, satellite data complements rather than replaces bottom-up inventories, supporting more complete and transparent national reporting.

Use Case 4: Informing Methane Regulation

The greatest regulatory value of satellite data emerges when it is used consistently over time, rather than for individual detections alone. The report shows how satellite observations can be integrated into structured regulator–operator workflows, supported by national registries that track detections, follow-up actions, and outcomes. As this information builds up, regulators gain insight into recurring emission sources, typical mitigation timelines, and patterns across facilities or regions. These insights support more data-driven regulatory decisions.

Across all four use cases, the report highlights that satellite data is most effective when used as complementary evidence alongside operational data and ground-based investigations. Satellites do not provide a complete picture of methane emissions on their own, but when integrated into structured processes, they offer a valuable, independent source of information that improves transparency, prioritisation, and decision-making.



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Abbreviations

IPCC	Intergovernmental Panel on Climate Change
UNFCCC	United Nations Framework Convention on Climate Change
OGI	Optical Gas Imaging
LDAR	Leak Detection and Repair
VRU	Vapor Recovery Unit
IMEO	International Methane Emissions Observatory (UNEP)
UNEP	United Nations Environment Programme
MARS	Methane Alert and Response System
TROPOMI	TROPOspheric Monitoring Instrument (on ESA's Sentinel-5P)
PRISMA	PRecursore IperSpettrale della Missione Applicativa (Italian hyperspectral satellite)
EMIT	Earth Surface Mineral Dust Source Investigation (NASA instrument)
AVIRIS-NG	Airborne Visible/Infrared Imaging Spectrometer – Next Generation
AVIRIS-3	Third-generation Airborne Visible/Infrared Imaging Spectrometer
GAO	Global Airborne Observatory
GHGSat	Greenhouse Gas Satellite (commercial satellite operator)
PID	Process and Instrumentation Diagram
NASA	National Aeronautics and Space Administration
CO2	Carbon Dioxide
t/h	Tonnes per hour (emission rate unit)
kg/h	Kilograms per hour (emission rate unit)

Introduction

Methane satellites have been changing what regulators and operators can know about emissions and how quickly they can act on them. When GOSAT, launched by the Japan Aerospace Exploration Agency (JAXA) in 2009, became the first dedicated methane-capable satellite, it gave the world its first global, space-based view of methane concentrations. Since then, new generations of instruments – from broad-coverage global mappers to high-resolution point-source imagers – have transformed satellite data from a scientific resource into a practical tool for everyday methane management.

Today, satellites enable a range of practical use cases. Satellites help operators identify and address issues by flagging events like extinguished flares or equipment failures, allowing for rapid interim fixes while more permanent solutions are developed. Repeated observations support tracking progress on mitigation, enabling stakeholders to follow whether interventions have worked and whether emissions recur over time. In regions with limited ground-based detection capacity, satellite alerts provide critical visibility, empowering operators to act on emissions even with minimal resources. As highlighted in the UNEP Eye on Methane report, satellite data can also be used to identify illegal or unauthorized activities, such as unreported venting or third-party interference[1].

This report presents four use cases that illustrate how satellite data can support (1) **identifying emission sources**, (2) **advancing methane mitigation**, (3) **improving national methane inventories**, and (4) **informing regulation**.

Together, these use cases illustrate a broader shift in how methane can be managed – one in which regulators, operators and society at large have access to continuous, independent, and increasingly precise information about where emissions occur and at what scale.

To guide the reader through these use cases, the report is organized into five chapters.

Chapter 1 introduces the public satellite datasets and explains how to interpret the fields that matter most in practice.

Chapter 2 presents the first use case, showing how satellites can support source identification by combining desktop analysis with targeted ground verification.

Chapter 3 outlines how satellite observations can inform and prioritize mitigation actions.

Chapter 4 demonstrates how atmospheric observations can complement and strengthen national methane inventories.

Finally, **Chapter 5** illustrates how satellite data can be embedded into a regulator-operator workflow to support more transparent and data-driven methane regulation.

The report is intended for regulators and operators who want to use satellite data more effectively, providing the insights needed to turn satellite detections into consistent methane-management frameworks.

[1] UNEP (2025) An Eye on Methane 2025: From Measurement to Momentum. Available at: https://www.unep.org/resources/eye-methane-2025-measurement-momentum

What Can We Learn from Public Satellite Datasets?

01

The emergence of publicly accessible satellite data is fundamentally changing what regulators and operators can know about methane emissions and how quickly they can address them. Today's publicly available satellite data are no longer purely a research tool for scientists. A growing constellation of satellites is producing open data that helps detect, quantify and mitigate emission events. The information they provide is specific enough in location, large enough in geographic coverage, and frequent enough in time to support real operational and regulatory decisions, but it is important to recognise that satellite data still comes with practical constraints, such as detection thresholds, revisit gaps, and environmental conditions, meaning it cannot reveal the full emission picture on its own.

These datasets are answering questions that have historically been very difficult to answer from the ground alone:

- **Where are emissions occurring?** Satellites make it possible to identify locations with elevated methane levels.
- **How large are the emissions?** Flux estimates offer an indication of the magnitude of observed events.
- **How often do emissions occur?** Repeated observations help show whether emissions are recurring or one-off.
- **Which regions contribute most to overall methane levels?** Atmospheric measurements reveal larger-scale patterns and areas that disproportionately influence national or regional emissions.
- **Are reported emissions broadly consistent with what is observed in the atmosphere?** Satellite measurements can highlight places where observations and reported figures diverge.

Together, these dimensions shift the conversation from detection to quantification. This chapter explains what the data includes, what conclusions you can draw from it, and what its limitations are.

1.1 Navigating the Public Satellite Dataset Landscape

Public satellite data platforms provide a new perspective on the methane monitoring strategies. While there are several such platforms[2], two stand out as essential reference points for regulators and operators: Eye on Methane[3] and Carbon Mapper[4]. Both share the common purpose to make methane emissions visible, attributable, and actionable.

Eye on Methane is the public platform that publishes data from the Methane Alert and Response System (MARS)[5], the largest publicly available aggregator of satellite-derived methane data. Operated as a transparency initiative by the United Nations Environment Programme's International Methane Emissions Observatory (UNEP's IMEO), MARS consolidates data streams from more than 35 satellites and space-based sensors, including the global mapping satellite Sentinel-5P and the high-resolution missions EnMAP, PRISMA, Sentinel-2, the Landsat constellation, and others.

[2] For example, ESA's Copernicus Data Space Ecosystem, JAXA's GOSAT Portal, NASA's Earthdata Portal, NASA-JPL's VISIONS EMIT Open Data Portal, SRON's Methane Plume Maps.
[3] UNEP IMEO Eye on Methane data platform. Available at: https://methanedata.unep.org/map
[4] Carbon Mapper data portal. Available at: https://data.carbonmapper.org
[5] UNEP IMEO Methane Alert and Response System (MARS). Available at: https://www.unep.org/topics/energy/methane/methane-alert-and-response-system-mars

On the Eye on Methane platform, data is updated on a rolling basis with a publication latency of approximately 30 to 75 days. During this period, IMEO engages with parties associated with the sites where emissions have been detected. For any regulator or operator seeking to build a systematic, jurisdiction-wide view of methane emission patterns, Eye on Methane is the primary and most comprehensive source currently available in the public domain.

The Carbon Mapper data portal represents a newer generation of satellite-based methane sensing capabilities and the data generated from these direct observations. Carbon Mapper uses Planet's Tanager-1 satellite, the first in a planned constellation, to detect, quantify, and track methane emissions at high levels of sensitivity that outperform most publicly accessible alternatives.

Paired with data from NASA's EMIT instrument and airborne sensors, including AVIRIS-NG, AVIRIS-3, and the Global Airborne Observatory (GAO), Carbon Mapper delivers daily to weekly observations of emissions at the point-source level. Satellite detections are typically published after 30 days of acquisition. In addition to methane, the portal also provides data on carbon dioxide emissions, making it a versatile tool for greenhouse gas oversight.[6]

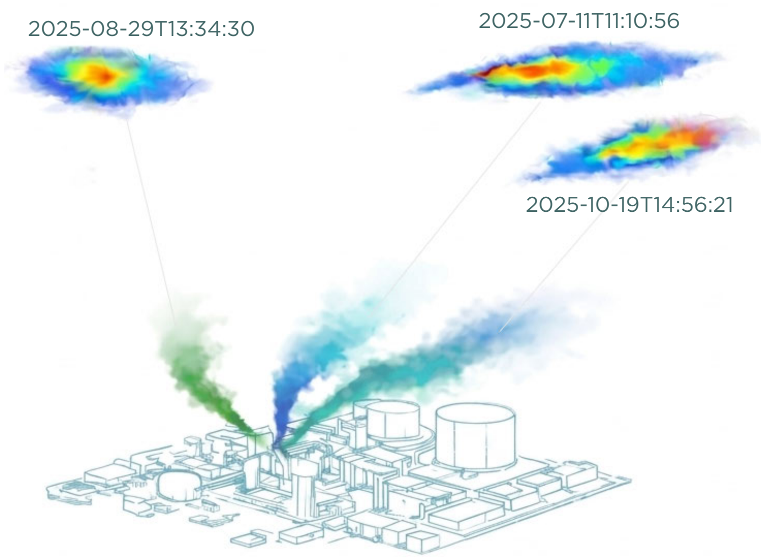
Both platforms allow users to download methane detection data, and readers are encouraged to explore their interactive maps. Taken together, these tools place a meaningful degree of satellite-derived emissions intelligence directly in the hands of regulators and operators worldwide. The following section walks through how to interpret what these platforms show, and what the data can and cannot reveal in practice.

1.2 Reading the Data: From Raw Fields to Actionable Insight

Satellite methane observations are published in structured formats that share a common logic across platforms. The emission data is typically organized into two primary datasets: plumes and sources. **Plumes** are an excess concentration of methane in the atmosphere emitted from a specific source. **Sources** are specific geographic locations from which emissions originate. Multiple plumes detected over time might be associated with a single source, as illustrated in Figure 1.

In the plume dataset, each record typically includes a plume identifier, the observing satellite, country, date and time of observation, geographic coordinates, sector classification, flux rate, associated uncertainty, wind parameters, and other metadata. Plume records are then grouped by location to form the source dataset, which compiles all detections attributed to the same emission point. The source dataset indicates how many plumes have been observed and attributed

Figure 1. Multiple satellite-detected plumes can be attributed to the same emission source over time.



Source: Carbon Limits

[6] Carbon Mapper's 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. Based on: Carbon Mapper data portal, Product Guide: Data Definition & Specification. Available at: https://carbonmapper.org/articles/product-guide.

to a given source, and how consistently that source has been emitting across the observation period. Below is a breakdown of the fields that matter most when drawing operational or regulatory conclusions.

Every plume detection record contains **geographic coordinates,** latitude and longitude, but how precisely do these numbers point to the actual infrastructure responsible for the emission?

These coordinates represent the best estimate of an emission source's location, inferred from the shape and concentration distribution of a plume compared to visible infrastructure on the ground. The comparison is performed through visual inspection using independent high-resolution satellite imagery and geographic information system (GIS) datasets.[7, 8]

The coordinates are accompanied by an uncertainty that depends on several factors, including the turbulent flow of a plume in the atmosphere and the spatial resolution of the instrument. For point-source imaging satellites such as Tanager-1, designed to attribute emissions to sources, this uncertainty is typically on the order of tens to low hundreds of meters – sufficient to identify a specific asset and sometimes a specific piece of equipment. For global mapping satellites such as TROPOMI, designed to track methane concentrations across larger areas, the spatial resolution of several kilometers makes attribution to a specific facility unreliable. As a rule, the actual source is likely to be located within 100 meters of the plume edges.[9]

Alongside location, each plume detection record includes an estimated **methane emission flux rate** – a measure of how much methane is being released into the atmosphere per unit of time, usually expressed in kilograms per hour.

Most instruments can detect emissions of roughly 500 kg/h and above[10], though more recent high-resolution instruments push this threshold considerably lower. Tanager-1, for example, has a detection limit of approximately 100 kg/h[8].

These estimates are derived from the observed plume concentration combined with wind speed analysis data and carry measurement and quantification **uncertainties**, which for most satellite instruments fall within the range of 20% to 50%.[7]

Flux rate values are a significant field in the dataset, providing a practical basis for prioritizing mitigation efforts. A site emitting at high rates across multiple detections requires more urgent attention than a single low-magnitude event, and flux data is a key input when deciding where to direct ground-level follow-up.

Source persistence is a metric available in the source dataset and is another important factor for prioritizing mitigation efforts. It denotes how often emissions are detected from a specific source over time. It can be approximately estimated by dividing the number of passes on which methane was detected by the total number of clear-sky observations. The resulting value ranges from 0 to 1, where values approaching 1 indicate a highly persistent source.

Some important considerations apply to the interpretation of this metric. In cases where the number of observations is limited, persistence values are not reliable and should not serve as a basis for comparison or prioritization. For sources with a sufficient number of observations, a high persistence value is a meaningful signal that calls for prioritized attention. A low persistence value, however, should not be interpreted as confirmation of an episodic source.

[7] UNEP IMEO Technical Documentation for Methane Satellite Detection and Quantification. Available at: https://wedocs.unep.org/items/c77a439f-9689-4164-874d-d49045e6d097
[8] Carbon Mapper Quality Control Description Document. Available at: https://assets.carbonmapper.org/documents/Carbon-Mapper-Plume-Detection-Quality-Control-Public.pdf
[9] Oil and Gas Climate Initiative (2025) Satellite methane detection response playbook. Available at: https://www.ogci.com/wp-content/uploads/2025/11/251119_OGCI_Methane_Playbook_FINAL.pdf
[10] IMEO Eye on Methane data platform, Data Dictionary. Available at: https://methanedata.unep.org/map

It may equally reflect emissions that fall below the satellite's detection threshold. Persistence is therefore most informative when considered together with observation frequency, flux rate estimates, and knowledge of the likely emission root cause.

Satellite detections are, first and foremost, tools for identification, establishing that an emission is occurring at a given location, at a given time, and at a meaningful scale. The flux rate and persistence values described above carry considerable uncertainty, meaning that satellites should not be regarded as tools for precise emissions estimates. However, the most consequential step in any emissions management approach is not precise quantification, but consistent monitoring, as it leaves little room for significant emissions to go unnoticed. Satellite data establishes an independent and increasingly comprehensive record of where methane is being released. For regulators and operators, that information, understood within the limitations of satellite technology, is a valuable asset on which effective action can be built.

1.3 Practical Considerations When Using Satellite Data

Methane tracking satellites have transformed the visibility of emissions across the globe, providing an independent and scalable source of information. The following outlines the key constraints that should be kept in mind when interpreting this data in an operational or regulatory context.

Satellites cannot detect emissions that fall below the instrument's **minimum detection limit,** defined as the lowest emission rate at which a satellite can reliably identify a methane plume under good atmospheric conditions. Below this threshold, a source may be emitting continuously without appearing in any satellite record. This means that a significant share of real-world emissions, including many smaller but persistent leaks, remain invisible. Oil and natural gas emissions visible to the TROPOMI instrument, which has a detection limit above 10,000 kg/h, are estimated to represent only 8–12% of total estimated emissions from the sector.[11] Therefore, satellites capture only a subset of actual occurring emissions, not a complete inventory.

A satellite's ability to detect methane depends on reflected sunlight in the shortwave infrared spectrum, which means that **surface and atmospheric conditions** directly affect performance. Cloud cover, even partial, physically blocks the ground from view and introduces noise into measurements. Water surfaces, snow, and dark, densely vegetated terrain all reduce retrieval quality, making methane detection in these environments substantially more difficult. Offshore methane plumes, in particular, are harder to detect over open water due to their low reflectance. As a result, effective detection thresholds can be substantially higher under certain regional and climatic conditions, meaning that the same emission rate may be detectable in one region but not in another.

Coverage and revisit frequency introduce a further constraint. Orbital geometry means that some locations are observed less regularly than others, and a given asset may fall within an instrument's field of view only a limited number of times per month or year. Infrequent revisits reduce the probability of capturing short-duration or intermittent emission events, and a sparse detection record should not be interpreted as evidence of good performance without first understanding the underlying observation frequency.

[11] Lauvaux, T. et al. (2022) Global assessment of oil and gas methane ultra-emitters. Science, 375, 557–561. Available at: https://doi.org/10.1126/science.abj4351

As mentioned before, emission **flux estimates derived from satellite data are subject to significant uncertainties.** Emission rates are not measured directly. Instead, they are inferred from the observed methane plume together with assumptions about atmospheric conditions and other parameters. Additional uncertainty can arise from factors such as resolution, cloud interference, surface reflectivity, the difficulty of separating emissions from complex or overlapping sources, and others. For these reasons, satellite-based flux estimates should be understood as approximate values, more reliable for indicating the order of magnitude of an emission event than for determining a precise release rate.

Satellite methane observations are **not published in real time.** Data processing is required before observations can be released, meaning there is always a delay between when an emission is observed and when that information becomes available. Some frameworks, however, can accelerate access. Under MARS, managed by UNEP's IMEO, detected emission events are communicated directly to governments and Oil and Gas Methane Partnership 2.0 (OGMP 2.0)[12] member companies ahead of public release (within 15 days of the event), enabling earlier response.

Taken together, these limitations mean that satellite data alone cannot serve as the basis for a complete facility-level emissions inventory or a mitigation strategy. Ground-level monitoring technologies remain essential for accurate emission measurement and for detecting releases that fall below current satellite detection thresholds. Therefore, satellites do not substitute for these methods. The unique value of satellites lies in establishing a consistent, independent record of where significant emissions are occurring. Within that role, and understood within its constraints, satellites are a distinctly powerful layer of intelligence in the monitoring framework.

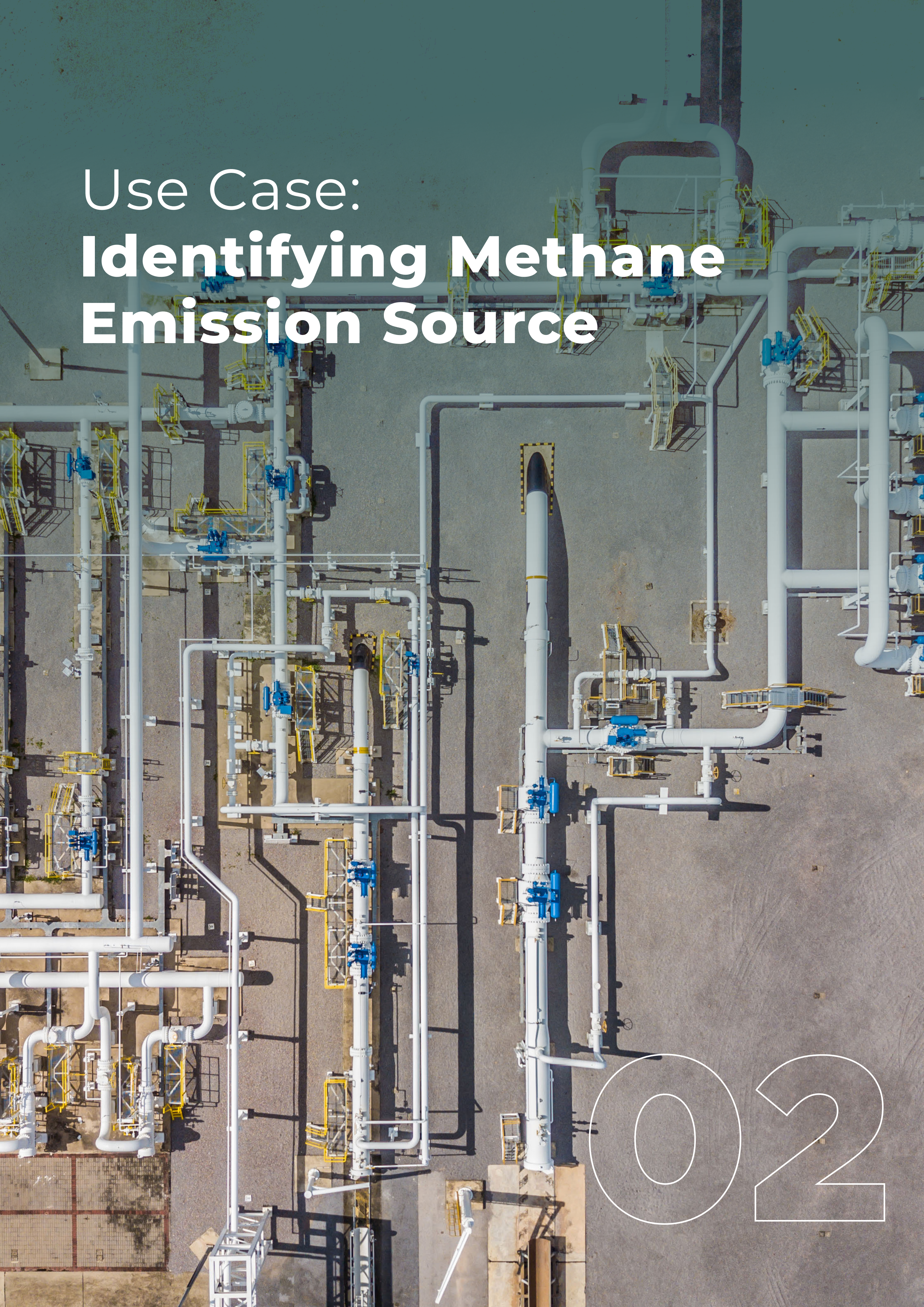
Key takeaways

Methane-tracking satellites are primarily designed to monitor super-emitting events, defined as emissions of 100 kg/h or more. Within the public data landscape, two platforms stand out: Eye on Methane, the largest aggregator of public satellite data, and Carbon Mapper, which offers a more sensitive satellite capability through its growing constellation. Although satellite data is becoming increasingly comprehensive, it must still be interpreted with a clear understanding of its limitations. Detection thresholds, revisit frequency, data latency, climate and surface conditions, and uncertainties in flux estimation all influence what satellites can reveal in practice. Their greatest value lies not in providing a complete inventory or precise measurement, but in identifying significant emissions, prioritizing follow-up, and building a systematic picture of the super-emitter emission patterns over time.

[12] The Oil & Gas Methane Partnership 2.0 is the United Nations Environment Programme's oil and gas reporting and mitigation programme. Available at: https://www.ogmpartnership.org/

Use Case:
Identifying Methane Emission Source

02



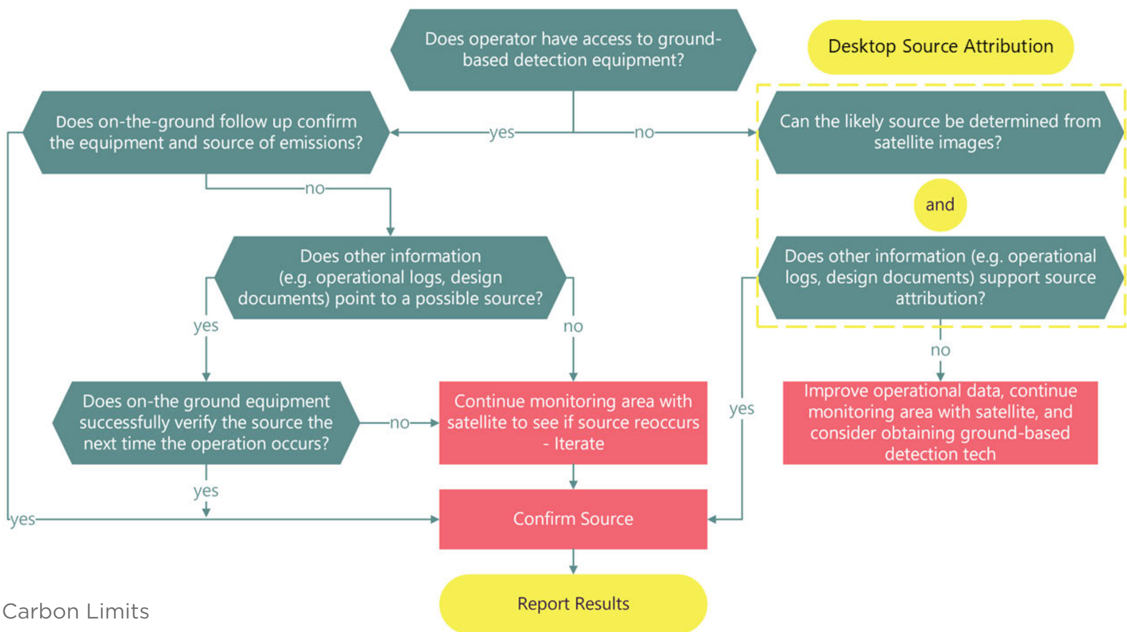
Combining satellite data with ground-based detection offers an efficient approach to optimise methane detection cost and required manpower. Satellite data guide operators toward super-emitters in the intervals between scheduled ground campaigns and ensure coverage of remote or geographically distributed facilities, where ground detection alone would be costly and logistically complex. The complementarity of these two approaches comes with a practical challenge: correlating satellite observations with ground-based findings is complicated by data latency and emissions variability. For example, a cold flare event captured in a satellite pass may no longer be present by the time the data reaches the operator two days later if the flare has since been re-ignited. The satellite record and the operational reality can diverge within hours. In most cases, satellite data alone is not sufficient to confirm a source and its root cause. A ground-based detection provides the verification that remote sensing cannot.

For super-emitters, source identification can be structured as a two-step process:

1. **Desktop source attribution.** Before any ground truthing, satellite imagery and available operational data are used to narrow the list of potential sources. This analysis serves two purposes: it helps ground operators prioritise where to direct their efforts, and it provides an initial validation layer when multiple potential sources have been detected in the same area.
2. **Ground truthing.** A targeted field investigation then confirms or refines the attribution established at the desktop stage, where possible, and supports root cause identification. The ground-truthing process is shown in the decision tree in Figure 2.

This chapter explains how desktop attribution and ground truthing work in practice, what each can reliably establish, and where the boundaries of each approach lie.

Figure 2. Ground truthing decision tree



Source: Carbon Limits

2.1 Desktop Source Attribution

Desktop source attribution begins with identifying the infrastructure within the detection area. At this stage, satellite imagery (such as Google Maps or Microsoft Bing Maps) can be used to examine the facilities in question. Access to process and instrumentation diagrams (PIDs) for the corresponding site further supports the analysis, helping operators avoid misattribution and account for equipment that may not be visible in aerial imagery.

The complexity of this step depends on the density of equipment at the facility. In remote areas, where the number of potential sources is limited, attribution is usually straightforward, for example, emissions resulting from a well pad located in the desert. In congested facilities, however, the task becomes significantly harder: when storage tanks, compressors, and flares are located in close proximity, a single satellite detection may point to several plausible sources. Underground piping and outdated satellite imagery add further uncertainty. In these cases, desktop analysis alone is unlikely to resolve the attribution, reinforcing the need for ground truthing.

The second stage of the desktop analysis incorporates the characteristics of the satellite detection itself. Emissions rate, detection frequency, and the date and time of each observation can help to narrow the list of candidate sources identified earlier, as indicated in Table 1. Cross-referencing these characteristics against operational data increases the probability of attributing the detection to a specific source. Operational data such as maintenance records, operation event data (e.g. well testing), and process variation are crucial to narrow down the list of emission source possibilities

Table 1. Satellite detection characteristics for source attribution

NO.	CHARACTERISTIC	ANALYSIS APPROACH	EXAMPLE
1	Emission rate	Indicates the likely equipment type based on the volume of emissions, allowing low- and high-emitting sources to be distinguished.	The maximum blowdown volume from a separator can be estimated from its size, providing a reference against which the detected rate can be compared.
2	Detection frequency	Frequency indicates whether emissions are continuous or intermittent.	A blowdown event will typically appear as a short-duration, high-intensity detection. A leak, by contrast, will appear persistently as long as the equipment remains under pressure.
3	Date and time	Can reveal contextual patterns such as planned shutdowns, seasonal variation of emissions, or seasonal operational practices.	Blowdown events carried out to prevent hydrate formation may occur only during winter months, with no equivalent detections in summer.

The output of this desktop process is a ranked list of the most probable emission sources. The list is not exhaustive, but it provides the basis for an efficient ground campaign. Feedback from field operators following ground detection is equally important: it refines the attribution methodology over time and makes successive analyses more accurate.

Following the analysis, the operator has reviewed its operational activities in the indicated location, on the dates of detection, and confirmed the gas was routed to a "vent sump" as a result of emergencies during well testing activities.

2.2 On-the-Ground Source Identification

Following the desktop analysis, an on-site visit is essential to confirm the potential source and establish the reason for the emissions, for example, whether the detection corresponds to a leak or a deliberate vent from a wellhead. Ground truthing should be carried out by qualified personnel equipped with appropriate detection tools, such as an Optical Gas Imaging (OGI) camera. Where reporting requirements apply, quantification instruments can also be deployed to measure emission rates in the field.

The scope of the ground truthing depends on the outcome of the desktop analysis. Where a single source has been identified, the visit serves to validate the attribution and determine the precise cause of emissions. Where multiple candidate sources remain, additional effort is required: the operator must first locate the relevant equipment and then establish the reason.

Box 1. Desktop analysis example

Carbon Limits has extensive experience in the desktop analysis of satellite methane emissions detection. The team has previously collaborated with GHGSat and the Oil & Gas Climate Initiative (OGCI) to review satellite data in four countries: Algeria, Egypt, Kazakhstan and, Iraq. The results were summarized in two white papers published by OGCI.[13, 14]

During the collaboration with the regulator in Bahrain and Kazakhstan, the Carbon Limits team supported the operators in reviewing a number of recurring emission sources detected by public satellites. For example, the team analyzed the emission source presented in Figure 3. Following the analysis of the detection frequency, emission rate and satellite imagery, the emissions were attributed to a venting/burning pit as the most probable source.

Figure 3. Satellite detection retrieved from Carbon Mapper

[13] OGCI (2023) Results of OGCI satellite monitoring campaign in Iraq. Available at: https://www.ogci.com/methane-library-item/results-of-ogci-satellite-monitoring-campaign-in-iraq/
[14] OGCI (2024) Results of OGCI satellite monitoring campaign 2022-2023 over Kazakhstan, Algeria and Egypt. Available at: https://www.ogci.com/methane-library-item/results-of-ogci-satellite-monitoring-campaign-2022-2023-over-kazakhstan-algeria-and-egypt/

Ground truthing can be omitted only in cases where the desktop analysis and operational records together establish with high confidence the reason for the event, i.e. the event was a planned venting operation. In all other cases, field verification remains necessary.

The findings from each ground truthing exercise should be recorded alongside the results of the desktop analysis. Over time, this combined dataset builds a track record of emission events, improves the accuracy of future source attributions, and informs maintenance and operational decisions aimed at reducing super-emitter occurrences. The approaches for managing this data, including registry design and data management, are covered in Chapter 5.

Not all detections will be resolved in a single cycle. On-ground source identification is not always conclusive, due to several reasons, including: (1) the time delay between satellite detection and detection on ground, and (2) the variability/intermittence of the emissions source itself. Where desktop analysis and ground truthing fail to confirm a source, this may be due to inconclusive operational data, access limitations, or the emission no longer being present. Regular satellite monitoring can allow for determining if the emission recurs. A recurring detection at the same location may require a follow-up ground campaign once conditions allow. Identifying the emission source is a critical step, but it does not by itself explain why an emission is occurring. Once a source has been attributed through satellite analysis and, where possible, confirmed on the ground, the focus shifts from where the emission originates to what is driving it. This transition is necessary because effective mitigation depends on the underlying factors that caused the emission to occur in the first place.

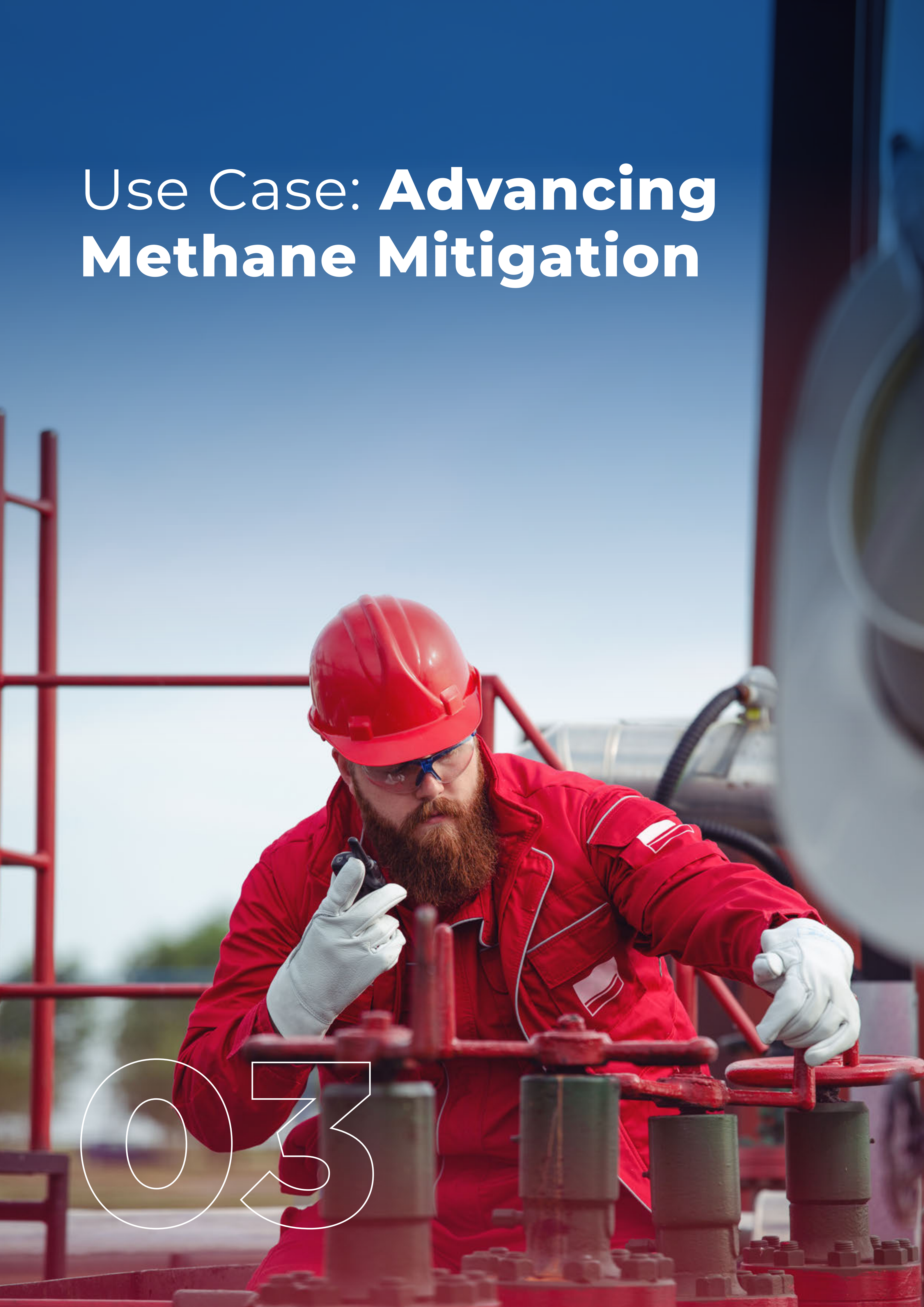
Root cause identification builds on source attribution by examining why an emission occurred.[15] This step combines information from satellite detections, site-level observations, operational records, and operator input to distinguish between causes such as equipment failure, operational practices, maintenance gaps, or design limitations. Understanding these drivers is essential for selecting appropriate mitigation measures, as similar emission sources may require very different responses depending on the root cause. This link between identification and mitigation is explored further in the next chapter.

Key takeaways

Identifying the source of a satellite-detected emission requires combining remote sensing with operational knowledge and, in most cases, ground-based verification. A structured two-step process – desktop source attribution followed by ground truthing – allows operators to prioritise effort and establish the root cause of emissions. The value of this process compounds over time: each resolved detection improves the accuracy of future attributions and builds an operational picture of emission patterns across facilities.

[15] OGCI (2026) Root Cause Analysis of Methane Emissions in the Oil and Gas Sector. Available at: https://www.ogci.com/wp-content/uploads/2026/03/260302_OGCI_RootCauseAnalysisReport.pdf

Use Case: **Advancing Methane Mitigation**



03

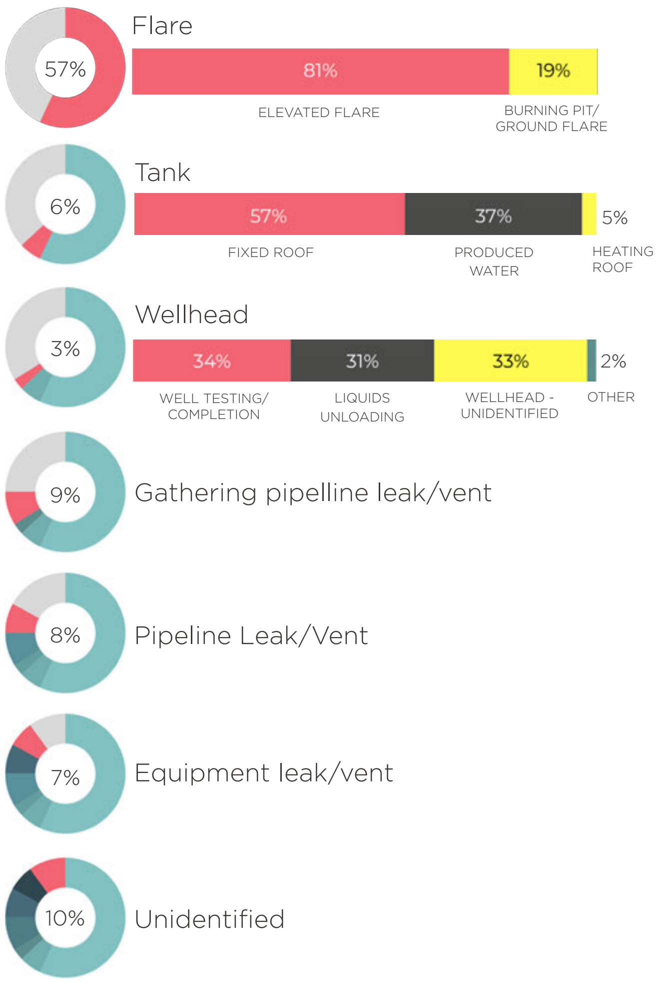
Satellite-detected methane emissions provide a signal that something on the ground requires attention and can serve as a practical starting point for mitigation. When a plume is observed, the satellite record helps operators narrow down which asset is most likely responsible and outline the range of feasible interventions, from immediate fixes to more complex mitigation options. As discussed in Chapter 2, some sources can be identified with high confidence from imagery alone, allowing an initial screening of possible mitigation pathways. However, in most cases, remote observations indicate where to focus attention, and on-the-ground assessment is needed to confirm the root cause and determine the appropriate intervention. This use case illustrates how satellite-detected emissions can prompt mitigation actions across a range of source types. For each source identified through satellite observations, potential mitigation pathways typically span low-, medium-, and high-complexity options, enabling operators to select an approach suited to the site conditions and underlying cause.

3.1 Findings from Satellite Observations

A recent study found that flares (including ground flares) accounted for around 57% of the super-emitters in the subset of detections it analysed, with pipelines, tanks, and wellheads appearing as the next largest source categories (see Figure 4).[16]

The findings from this study provide insight into how satellite data may be used to inform mitigation. Satellite data can often narrow down the likely emission source type – such as distinguishing flares, tanks, wellheads, or pipelines – and provide an initial sense of feasible mitigation options. However, satellites cannot diagnose why an emission is occurring: for example, an elevated flare visible in imagery may reflect cold flaring, inefficient combustion, accidental extinguishment, or another operational issue. Implementing the appropriate mitigation measure in most cases requires combining satellite observations with operational data, site-specific insights, and ground-level investigation to understand the root cause and select the most suitable mitigation option. Mitigation decisions informed by satellite data should thus be viewed as preliminary, and solutions applied on a case-by-case basis rather than through a one-size-fits-all approach that will work for all sites and operators.

Figure 4. Contribution of methane emissions from various source types



[16] Carbon Limits and GHGSat (2024) Perspectives on Methane Super-Emitters: Determining Emission Sources using Satellite Detections. Available at: https://www.carbonlimits.no/projects/methane-super-emitters-kizd1

3.2 Mitigation Pathways Identified via Satellite Data

Once the likely emission source type and root cause have been established, it becomes possible to consider a range of mitigation options, which differ significantly in complexity, required equipment, and implementation effort. Some cases allow for quick fixes, while others require more substantial interventions. . Mitigation can range from repairing, upgrading, replacing, or decommissioning equipment to improving maintenance and operational practices, and in some cases, focuses on addressing upstream root causes rather than the emitting source itself.[17] Broadly, mitigation approaches fall into three levels of complexity:

- **Low complexity** options require little to no new equipment, as well as minimal manpower and limited time (approximately a few hours to a day) to implement. These are "quick fixes" such as repairing an equipment or temperature monitoring/installing a thermocouple on flares.

- **Medium complexity** options may require new equipment or equipment upgrades. Implementation of these options is generally not overly complicated, but may require more manpower or time. Medium-complexity solutions include flare replacement and installation of a vapor recovery unit (VRU).

- **High complexity** options are more involved, potentially requiring a process or equipment overhaul. Significant manpower and/or time is required to coordinate and implement these solutions, which include options like gas utilization programs.

[17] Oil and Gas Climate Initiative (OGCI) (2026). Root Cause Analysis of Methane Emissions in the Oil and Gas Sector. OGCI. Available at: https://www.ogci.com/wp-content/uploads/2026/03/260302_OGCI_RootCauseAnalysisReport.pdf

Table 2. Mitigation options for flares, gathering pipelines, and tanks

EMISSION SOURCE TYPE	MITIGATION OPTIONS		
	LOW COMPLEXITY	MEDIUM COMPLEXITY	HIGH COMPLEXITY
Elevated or ground flare	If the root cause of the emission is unlit venting as a result of an accidentally extinguished flare, an auto-ignition system or warning system can be installed as a preventative measure.	If the flare handles both gas and liquids, changes in upstream separation could improve the flare efficiency. If not, and if the flare is old or otherwise inefficient, replacing or improving the flare could improve combustion efficiency (e.g. via improved flare tip design or flare ignition system).	Ideally, flaring is avoided in the first place: instead of sending gas to flare, a gas utilization program can be implemented to capture the gas for onsite use or sale. Gas utilization routes can range from small to large scale depending on the volume of recovered gas, and cover a range of uses including gas reinjection, onsite heat/electricity, sale of chemical products, and sale of gas and processed products.
Gathering pipeline	If the root cause is a leak from a loose valve, the fix could be as simple as tightening or replacing the valve. After mitigation is complete, regular pipeline monitoring in the form of leak detection and repair (LDAR) campaigns can support more timely repairs and minimize future methane emissions.	If the emission is the result of pipeline failure, the pipeline segment will need replacement. After mitigation is complete, regular pipeline monitoring (including LDAR campaigns and structural integrity monitoring) can help prevent future major leak events.	For manual venting events, a portable flare with separator could be used to reduce the volume of vented gas. If venting occurs due to hydrate formation, methanol injections could prevent hydrates from forming in the first place, reducing the frequency of blowdowns.
Storage tanks	In the case of faulty equipment, roof or tank restoration could prevent further emissions. Floating roofs are a good option as they fluctuate with the level of the tank liquids, reducing the vapor space and minimizing evaporative losses.	Improved upstream separation/stabilization could remove gas from oil before the latter reaches the tank, preventing these gases from accumulating in the tank.	Accumulated vapors could be routed to a flare or collected in a vapor recovery system to prevent them from being released to the atmosphere.

The chosen level of complexity will depend on a variety of factors, such as the size, intermittency, and root cause of the emission. Generally, a higher complexity option will result in higher costs. However, the absolute costs of different mitigation options are dependent on many conditions, including emission size, region, facility age, and technology availability. In some cases, it may be possible to simultaneously address several emission sources with a process or equipment overhaul, which could make a high complexity option preferable.

Table 2 summarizes some source-specific examples of low, medium, and high complexity mitigation options.

Satellite data can also help prioritize mitigation efforts: estimated flux rates and persistence highlight which emissions require the fastest response, with high-flux and continuous emissions typically treated as higher-priority cases because of their disproportionate climate impact. Repeated intermittent detections from the same source can indicate an underlying operational practice – such as venting before maintenance – that may need to be changed to prevent recurring emissions.

Another important way satellites can support mitigation is through follow-up monitoring. Post-mitigation checks using satellites can help indicate whether emissions reappear at the same location. However, as discussed in Chapter 1, satellite observations come with practical constraints, so a post-mitigation non-detection should be treated as a useful indication rather than confirmation that emissions have stopped.

For this reason, satellite checks should be paired with field verification, for example, using OGI or other on-site measurement tools to confirm that the source is no longer emitting, and with operational performance checks that review system data, such as pressures, temperatures, or flow and control responses, to ensure the equipment is functioning normally over time.[18]

Key takeaways

Satellite observations can guide targeted methane mitigation by identifying high-emitting and persistent sources, helping operators prioritise where to act. However, effective mitigation still depends on ground-level investigation to diagnose root causes and on follow-up monitoring to verify whether mitigation efforts have been successful.

[18] OGCI (2025) Satellite methane detection response playbook. Available at: https://www.ogci.com/wp-content/uploads/2025/11/251119_OGCI_Methane_Playbook_FINAL.pdf

Use Case: **Informing Methane Inventory**

04

Satellite data can strengthen bottom-up national methane inventories by providing more comprehensive coverage of emission sources and revealing missed and unreported events, including super-emitting releases that are often underrepresented in bottom-up reporting systems. When integrated with national sectoral reporting frameworks, satellite-derived information can help assess differences between top-down and bottom-up emission estimates.

As observational coverage continues to expand through new satellite missions and instruments – including Eye on Methane and Carbon Mapper – the role of satellites in national inventory improvement is expected to grow, enhancing transparency, reducing uncertainty, and complementing established bottom-up methodologies.

4.1 Systematic Discrepancies Between Bottom-Up and Top-Down Emission Estimates

Inventories based on bottom-up emissions calculation can either underestimate or overestimate methane emissions. Across global, regional, and basin-scale analyses, satellite-based observations consistently reveal substantial discrepancies with source-level methane inventories. Most studies point to systematic underestimation – often by 30–50% or more – particularly in oil and gas production regions. In specific operational contexts, however, bottom-up approaches can overestimate emissions. Together, these findings show that inventory biases vary by region and production profile, reinforcing the value of satellite observations in diagnosing gaps, improving completeness, and strengthening national methane inventories. Table 3 summarizes the findings from several recent studies.

These studies provide strong empirical evidence that discrepancies in methane emission estimates can occur in both directions depending on regional characteristics and production profiles. This discrepancy also highlights the need for accurate data to track progress in reducing emissions by companies and countries implementing mitigation measures. They also illustrate the growing role of satellite observations in diagnosing inventory biases and improving emission estimates.

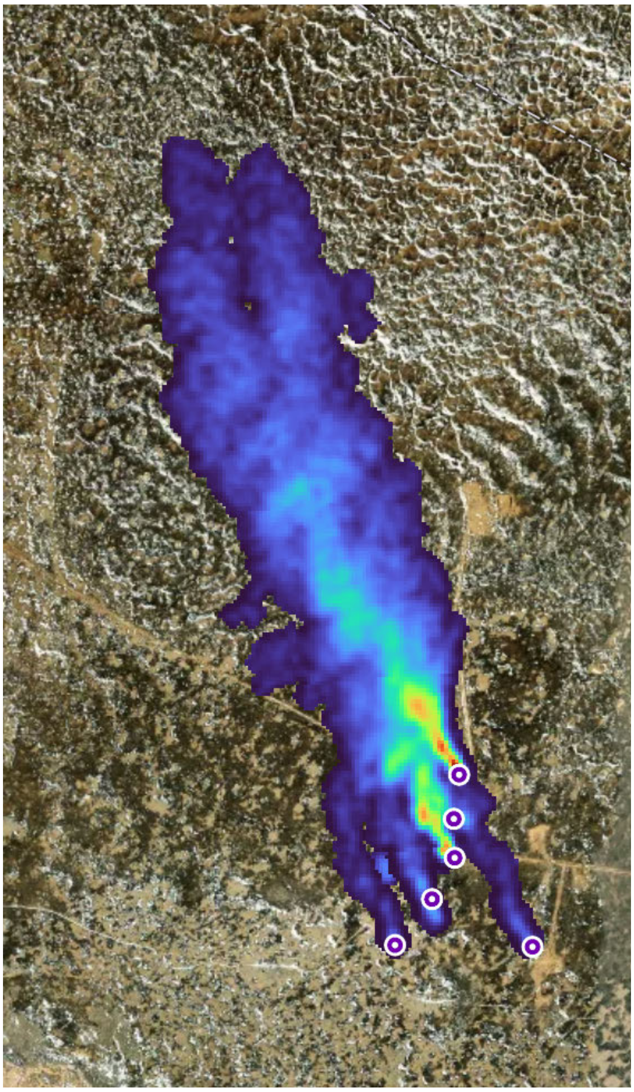


Image: Carbon Mapper

Table 3. Evidence of discrepancies between bottom-up inventories and satellite-based methane estimates

STUDY TYPE	SPATIAL SCALE	SATELLITE APPROACH	DIRECTION OF BIAS	MAGNITUDE OF DISCREPANCY	DIRECTION OF BIAS
Global inversion of national inventories[19]	Global (161 countries)	TROPOMI + inverse modelling	Underestimate globally, however, country-level comparisons show deviations in both directions	+15% total anthropogenic; +30% oil & gas	Bottom-up inventories systematically underreport emissions, particularly in the oil and gas sector
High-resolution sectoral inversion[20]	Global fossil fuel regions	TROPOMI + regional inversions	Underestimate	+30% oil & gas	Emission factor approaches fail to capture real-world variability and high-emitting sources
Basin-scale case study (Canada)[21]	Regional production basin	TROPOMI concentration enhancements	Strong underestimate	~7× higher than inventory	Persistent facility-level emissions missing from bottom-up accounting
System-wide basin analysis[22]	200+ oil & gas regions	MethaneSAT area flux mapping	Underestimate	~50% higher than inventories	Comprehensive atmospheric coverage reveals widespread underreporting
Oil-dominated basins[6]	Selected regions	MethaneSAT	Overestimate	~30% lower than inventories	Emission factors can overstate emissions where operational profiles differ

[19] East, J.D., Jacob, D.J., Jervis, D. et al. (2025) Worldwide inference of national methane emissions by inversion of satellite observations with UNFCCC prior estimates. Nature Communications 16, 11004. https://doi.org/10.1038/s41467-025-67122-8

[20] Shen et al. (2023) National quantifications of methane emissions from fuel exploitation using high-resolution inversions of satellite observations. Nature Communications. https://www.nature.com/articles/s41467-023-40671-6

[21] Dubey et al. (2024) Comparing satellite methane measurements to inventory estimates: A Canadian case study. Atmospheric Environment X, Vol. 17. https://doi.org/10.1016/j.aeaoa.2022.100198

[22] MethaneSAT (2026) The world according to MethaneSAT: Oil & gas methane emissions vary widely by region, greatly exceed both reported inventories and industry goals. https://www.methanesat.org/project-updates/first-look-system-wide-view

4.2 IPCC Guidance on the Use of Satellite Data

The 2006 IPCC Guidelines, the internationally agreed framework for how countries calculate and report greenhouse gas emissions, and their 2019 Refinement[23] do not require satellite data as an input to national methane inventories, but recognise that they can contribute to inventory development, quality assurance, and progress toward higher-tier methodologies. Within that framework, satellite data functions as complementary evidence, not a substitute for bottom-up calculations.

Atmospheric measurements are recognised as a valid basis for inventory verification. Comparing reported bottom-up emissions against independent atmospheric observations can reveal inconsistencies, systematic biases, or unexplained trends, helping assess whether national estimates are plausible. These comparisons are intended to operate at a national or regional scale, not to replace inventory calculations or directly generate reported emission figures.

Satellite observations are frequently analyzed using inverse modelling, which infers emissions by working backwards from observed atmospheric concentrations. However, inversion results are highly sensitive to atmospheric transport modelling assumptions (e.g. how emissions are transported and dispersed in the atmosphere), prior estimates (reported emissions), and the geographic coverage of available data. Countries including Switzerland, the United Kingdom, and the United States are cited as examples of how this can work in practice.

When discrepancies arise between satellite-derived estimates and national inventories, the Guidelines do not interpret them as evidence of error. Instead, they point to where further investigation, improved activity data, or methodological refinement may be useful. Overall, the IPCC positions satellite data as an enabling input for verification and continuous improvement, helping strengthen inventory robustness and transparency over time.

4.3 Approaches to Integrating Satellite-Derived Emissions into National Inventories

Public satellite datasets provide observations from two broad types of satellite instruments: area flux mappers, which estimate emissions at aggregated spatial scales[24], and point source imagers, which detect and characterise individual emission events.[25] These two data types serve different purposes when it comes to informing methane inventories.

Area flux mappers observe observe atmospheric methane concentrations across large areas. Their primary value for national inventories is in identifying systematic over- or under-estimation in reported emissions at aggregated scales. When combined with atmospheric transport models and inversion techniques, these observations can be used to derive regional or national-scale methane flux estimates, providing an independent atmospheric perspective that can reveal discrepancies between reported emissions and observed atmospheric methane patterns (Table 4).

[23] 2019 Refinement to the 2006 IPCC Guidelines. Available at: https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/1_Volume1/19R_V1_Ch06_QA_QC.pdf

[24] As an area flux mapper, TROPOMI can only be used to pinpoint the sources of emissions from the largest and most isolated point sources. For more challenging sources, high-resolution instruments are more suitable to detect and identify the exact location of super-emitters. Based on: Schuit, B.J. et al. (2023) Automated detection and monitoring of methane super-emitters using satellite data, Atmospheric Chemistry and Physics, 23, pp. 9071–9098. Available at: https://doi.org/10.5194/acp-23-9071-2023

[25] Jacob, D. J., Varon, D. J., Cusworth, D. H., et al. (2022) Quantifying methane emissions from the global scale down to point sources using satellite observations of atmospheric methane. Atmospheric Chemistry and Physics, 22, 9617–9646. Available at: https://doi.org/10.5194/acp-22-9617-2022

Table 4. Characteristics and applications of area flux mappers

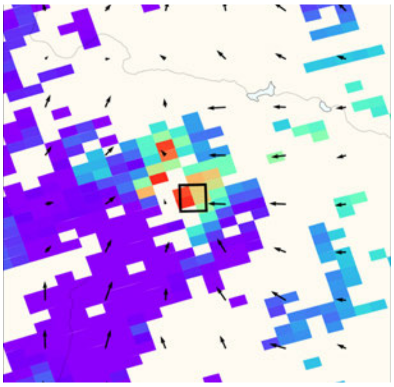


Image: Copernicus Sentinel data/SRON

Characteristic	Application
5.5 km x7 km (TROPOMI) 10-km diameter (GOSAT)	Estimation of regional fluxes through the inversion of atmospheric transport models
global daily coverage	Comparison of aggregated satellite-derived emissions against bottom-up estimates to identify discrepancies
>10 t/h threshold	Detection of individual ultra-emission events and hotspots (persistent and strong emission areas)
not designed for direct attribution to sources	Monitoring of changes in regional methane flux rates over time through frequent observations

When applied repeatedly over the same region, area flux mappers can also track changes in total emissions over time, helping assess how emissions respond to policy measures, management practices, or other interventions.[26]

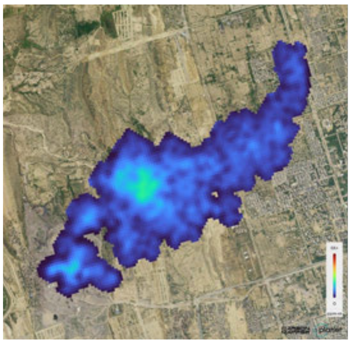
Area flux mappers are also effective at identifying persistent emission hot spots – large areas that repeatedly contribute disproportionately to national emissions. Such hot spots may reflect emission sources or operational practices that standard inventory methods don't capture well, pointing to where methodological refinement or additional data collection is needed.

Point source imagers operate at higher spatial resolution, capable of detecting methane plumes from individual facilities or pieces of infrastructure. Depending on the instrument and observing conditions, these systems can resolve emissions at scales of tens to hundreds of meters and estimate emission rates above defined detection thresholds.

These satellites do not observe all emission sources or provide continuous coverage. Instead, they capture only the larger events that are often underrepresented in emission factor-based inventory methods. Because these observations reflect only a subset of total emissions, plume-level emission rates combined with assumed emission durations should not be interpreted as capturing all unreported emission events. Instead, they provide evidence of significant emission events and represent an estimate of emissions from the detected sources (Table 5). Indicative emission estimates can be derived from these observations using the Methane Emission Estimator (see Box 2).

[26] Berkeley Law Center for Law, Energy & the Environment (CLEE) and UCLA Emmett Institute on Climate Change and the Environment (2025). Hunting Methane Using Satellites: A Guide for Policymakers. Available at: https://www.law.berkeley.edu/wp-content/uploads/2025/04/Hunting-Methane-Using-Satellites_CLEE_Apr2025-1.pdf

Table 5. Characteristics and applications of point source imagers



down to 30m/pixel	Detection and quantification of methane super-emitters
sparse acquisitions	Addition of missing point sources and correction of underestimated emission estimates
>0.1-1 t/h threshold	
attribution to sources	

Image: Carbon Mapper/ Planet Labs PBC

Overall, area-scale flux estimates offer a high-level assessment of whether national emissions are broadly consistent with atmospheric observations (as described in Section 5.2). Where systematic discrepancies emerge, inventory compilers can focus their attention on the specific regions or sectors flagged by this analysis. Point-source imagers can then help explain what is driving those discrepancies. By identifying recurring large emission events associated with particular infrastructure types, they can help answer the question of why aggregated emissions may diverge from reported values – whether that reflects emission factors that need revision or gaps in the completeness or granularity of activity data.

Key takeaways

Satellite observations provide an independent atmospheric perspective that helps identify where national methane inventories may be incomplete, offering insight into both national emission patterns and the contribution of large emitters. Used within the IPCC framework, this data serves as complementary evidence that strengthens inventory transparency and supports continuous improvement, rather than replacing established bottom-up methods.

Box 2. Tool Spotlight: Methane Emission Estimator

Carbon Limits developed the Methane Emissions Estimator as a practical tool for regulators to improve bottom-up methane inventories using publicly available satellite data. The tool processes detections derived by point-source imaging satellites and source data from the UNEP IMEO Eye on Methane platform to produce per-source mean emission estimates and associated uncertainties. These values are then aggregated to estimate total methane emissions by sector for any selected country and observation period.

This Excel-based tool requires three simple inputs: a country, a date range, and two UNEP IMEO export files (per-plume and per-source datasets). It automatically filters relevant observations, removes missing flux values, calculates weighted mean emissions per source, applies persistence factors, and produces sector-level emission totals and uncertainty estimates.

The Estimator improves understanding of national emissions by revealing large and persistent superemitters that conventional bottom-up approaches often underestimate.

Use Case:

Informing Regulation

05

Satellite-detected methane data provides regulators with data that can support more informed, transparent, and adaptive methane regulation. In addition to detecting and mitigating individual emission events, the systematic use of satellite data enables regulators to understand emission patterns, assess mitigation action effectiveness, and continuously improve technical standards and compliance frameworks.

To realise this value, satellite data must be embedded within a structured regulatory process that ensures consistent handling of detections, clear roles for regulators and operators, and consistent data management.

5.1 Satellite Data as an Input to Data-Driven Regulation

Satellite observations offer regulators several unique features complementary to traditional on-the-ground monitoring approaches. They provide independent coverage, enable identification of large and persistent emission sources, and allow emissions to be tracked over time across facilities and operators. Rather than being used for enforcement, satellite data is most useful when it supports regulatory decision-making, direct engagement with operators, and ongoing improvements to methane emission management.

The regulatory value of satellite data depends on how detections are recorded and linked to follow-up actions. A structured data management system allows regulators to move beyond individual cases and build an evidence base for trend analysis and regulatory insight. A national registry or database, maintained by the regulator, provides the foundation for this approach.

By linking satellite detections with information submitted by operators on source identification, root causes, mitigation actions, and timelines, the registry creates a consistent and traceable record of satellite-detected emission events.

As this dataset grows, regulators can draw practical insights, including:

- identification of equipment types or operational practices associated with repeated emissions;
- typical mitigation timelines and barriers to rapid repair;
- differences in emission patterns across facilities, regions, or operators;
- input to assessing whether existing technical standards or operational requirements are delivering expected emission reductions.

These insights can directly inform regulatory action. They support updates to technical standards or best-practice guidance, help refine reporting requirements and inspection priorities, and enable the design of targeted mitigation programmes for high-risk source categories. They also provide a shared evidence base for structured, evidence-based dialogue with operators on performance improvement. Over time, this approach supports a shift toward adaptive regulation, where requirements evolve based on observed performance and empirical evidence rather than static assumptions.

5.2 How to Set up an End-to-end Regulator–Operator Process

A structured regulator–operator process helps ensure that satellite data is handled consistently and in a coordinated way. The five-step framework illustrated in Figure 4 provides a generic, adaptable structure that regulators can use as a reference when designing or refining national approaches to satellite-informed methane regulation. The end-to-end regulator–operator process begins with the detection of methane plumes by satellites, which provide associated metadata on the location and characteristics of observed emissions. Relevant detections within the regulator's jurisdiction are registered and communicated to the potentially responsible operator. Operators then assess whether the detected emission is associated with assets or operations under their control, drawing on desktop analysis and, where appropriate, site-level investigation. Where an emission source is confirmed, operators implement mitigation actions and verify that emissions have been addressed, documenting both the actions taken and the associated timelines. This information is subsequently reported back to the regulator in a structured format, including details on emission sources, root causes, mitigation measures, and outcomes. The regulator reviews the submitted information, updates the national registry accordingly, and closes or maintains cases based on the evidence available.

As satellite coverage expands and detection frequency increases, defined workflows and responsibilities help regulators respond consistently. At the same time, transparent processes and clear expectations reduce uncertainty for operators.

Box 3. Policy Spotlight: National Guidelines on Satellite-Detected Methane Emissions

Carbon Limits developed the National Guidelines on Satellite-Detected Methane Emissions to give regulators a clear and practical way to work with satellite-detected plume data. The Guidelines were shaped through close collaboration with regulators in two countries, ensuring the framework reflects real constraints and current needs.

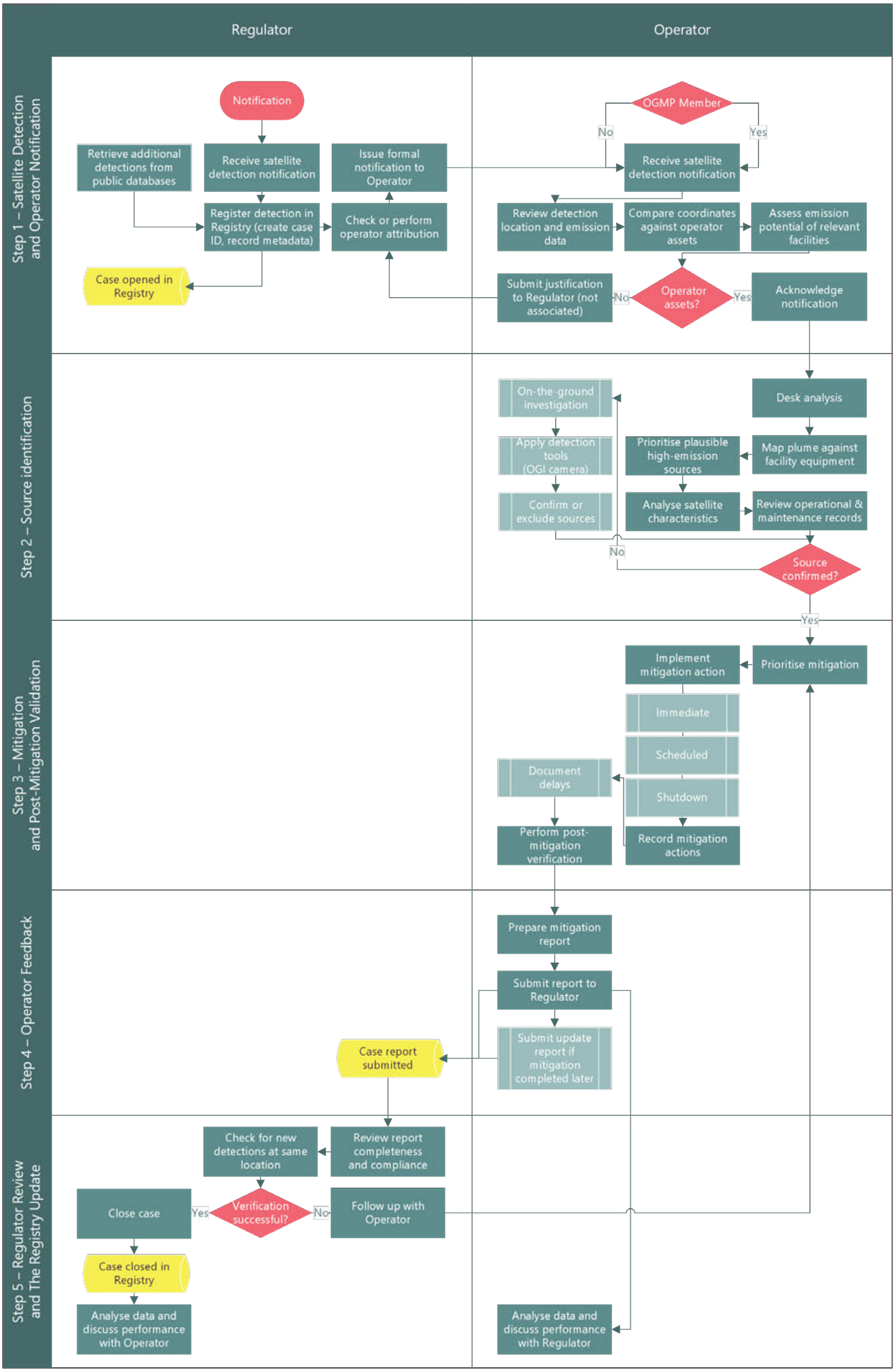
The Guidelines put the regulator at the center of the process: receiving detections, coordinating with operators, following up on cases, and keeping the National Satellite Methane Emission Registry – the country's running record of what was detected, what was done, and when. By defining who does what and when, the Guidelines turn satellite detections into a well-structured workflow instead of a series of ad-hoc actions.

At the heart of the Guidelines is a simple idea: satellite data becomes much more powerful when it sits inside a step-by-step national process. From the first notification to confirming that mitigation worked, the workflow helps connect data with real follow-up. Over time, the Registry grows into a history of recurring sources, the speed of operator response, and the types of mitigation that work (or do not). This evidence base gives regulators a clear picture of where problems repeat, how practices evolve, and where technical standards or methane regulations may need adjustments.

Key takeaways

Satellite data can support methane regulation when used as part of a systematic approach to data collection and analysis, enabling regulators to identify emission patterns, recurring sources, and trends over time. The regulatory value comes from consistent data management and repeated use of information across cases, rather than conclusions drawn from individual detections. Satellite data is therefore best used to inform regulatory improvement, not as an enforcement tool.

Figure 4. 5-Step Regulator-Operator Process



Conclusion

Satellite-based methane monitoring is no longer a niche capability. It became an operational asset that can strengthen how regulators and operators manage emissions. The four use cases presented in this report show that when satellite observations are interpreted correctly and linked to structured follow-up, they provide independent detection of large emission events, insight into recurring operational issues, a clearer understanding of discrepancies in national inventories, and a more consistent foundation for data-driven regulation.

For readers, the value of this report lies in what can happen next. Regulators may use these insights to design or refine national processes for handling satellite-detected emissions, set up or expand a methane emission registry, or incorporate satellite data into inventory QA/QC procedures. Operators may choose to integrate satellite observations into their LDAR planning, strengthen procedures for responding to alerts, or track the effectiveness of mitigation actions over time.

Ultimately, the report aims to help both regulators and operators move from awareness to implementation. By understanding what satellite data can reliably show, where its limitations lie, and how it fits into existing workflows, readers are better equipped to translate detections into concrete action. As satellite capabilities continue to expand, now is the best time to integrate satellite detections into methane-management frameworks and establish workflows that can fully leverage this new stream of data.

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