OIL AND GAS CLIMATE INITIATIVE

RESULTS OF OGCI SATELLITE MONITORING CAMPAIGN IN IRAQ

A WHITE PAPER FROM THE
OIL AND GAS CLIMATE INITIATIVE

JANUARY 2023

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Executive summary

The Oil and Gas Climate Initiative (OGCI) launched a Satellite Monitoring Campaign in 2021 to take practical action to help reduce methane emissions from oil and gas operations, demonstrate the capability of satellite technology to detect and quantify methane in Iraq and provide information to local operations to help them reduce emissions.

For this program, GHGSat performed over 175 high-resolution observations over six selected sites during a nine-month period, using its own satellites and public satellite data. Sites were selected on the likelihood of having facilities with observable methane emissions based on existing evidence of methane plumes, flaring volumes, age of infrastructure, size of the field and production volumes.

The Campaign demonstrated that there are challenges and opportunities associated with using satellite data and engaging with local operators to support mitigation of methane emissions. Opportunities may arise through an integrated approach, combining satellite observations and targeted peer engagement with the operators.

The main findings are:

- **There is significant potential for using satellite technology to detect observable methane emissions in Iraq and globally.** When detected, the methane emissions were significant with an average emission rate at the six assets of almost 1,500 kg CH4 per hour. Two of the plumes detected contributed more than 25% of the total detected emissions[1], while at two of the monitored assets, no emission sources above satellite detection threshold were observed during the monitoring period.
- **The satellite monitoring provided important information to operators, helping them to explore technical solutions for mitigation**. At one site, operators were able to make improvements in routine procedures, cutting repeatedly observed methane emissions in the range of 0.5 to 8.0 t CH_4/hour to a level not detectable by satellite over the course of a few months in 2022. However, some emission sources take longer to address and require larger capital investments. The most common emissions sources observed, established in communication with the operators, were associated gas flaring, direct venting, and maintenance events.
- **Satellites are capable of detecting and measuring methane emission sources from the oil and gas sector, but there are limitations.** Over 80% of the observations performed by GHGSat were successful. This means they were able to identify and quantify emission rates, where present, as low as 70 kg CH4/hour[2]. The remaining detections were inconclusive due to observation challenges such as the presence of water near to the source, cloud coverage and dust storms.

For all identified and attributed plumes from both public and GHGSat satellites, the Campaign team shared information promptly with the relevant operators to facilitate further investigation and, where applicable, mitigation. OGCI member company presence or relations with local operators facilitated effective and prompt reaction on the ground, leading to emission reductions. As more work remains to be done to address some of the earlier identified plumes and to mitigate identified methane sources, the Campaign will continue to provide capacity building with local operators in Iraq.

[1] Please note that plume observations are not independent and multiple detections at the same asset at different times are included in the analysis.

[3] Although it should be noted that no on-the-ground measurements were performed to validate the emission rates.

Given the promising results, the Campaign has now been extended to 20 sites across Iraq, Kazakhstan, Algeria and Egypt.

Why focus on methane?

Methane is a potent greenhouse gas responsible for around 30% of current global warming (IEA, 2022). Eliminating methane emissions from the oil and gas sector represents one of the best short-term opportunities for contributing to climate change mitigation. According to the International Energy Agency, almost a quarter of methane emissions caused by human activities (agriculture, energy, waste) come from the oil and gas sector.

The private and public oil and gas sector is coordinating voluntary action to support governments in the implementation of the recently launched Global Methane Pledge. OGCI is leading work to support methane emissions reduction globally across the oil and gas sector. It launched the Aiming for Zero Methane Emissions Initiative, helped to develop the Methane Guiding Principles (MGP) Flaring Toolkit and supported the development of Methane Inventory Systematic Tool (Mist) for oil and gas companies. It is also working on recommended practices for methane detection and quantification technologies.

The Satellite Monitoring Campaign

Looking for tangible actions that would impact methane emissions from the global oil and gas industry, OGCI set up a programme with GHGSat, a leading global expert in satellite monitoring of methane (and an investee of OGCI Climate Investments), and Carbon Limits, a technical partner with in-depth knowledge of methane emissions in developing countries, to explore the potential of using satellite monitoring to identify and provide information to mitigate significant emissions in Iraq.

The team engaged with local oil and gas operators to notify them of any detected methane anomaly. This process showcased the potential for real methane mitigation based on timely access to high-quality data. Important findings and early lessons learned from Iraq can inform future satellite monitoring programmes and assist other actors in the field aiming to use satellite capabilities to reduce methane emissions.

Details on the satellite monitoring technology and methodology for selection of monitoring sites and engagement with the local operators are provided in Appendix 1 to this paper.

Key findings

Overall results

GHGSat satellites

The first phase of the project demonstrated both the capabilities of satellites in detecting observable emissions and successful operator outreach. It also highlighted some limitations and challenges.

Over 80% of the observations performed by GHGSat were able to identify and quantify emission rates, where present. The remaining detections were inconclusive due to various observation challenges: presence of water near to the source, cloud coverage, dust storms etc. The GHGSat technology observed emissions as low as 70 kg CH4/hour[3].

[3] Although it should be noted that no on-the-ground measurements were performed to validate the emission rates.

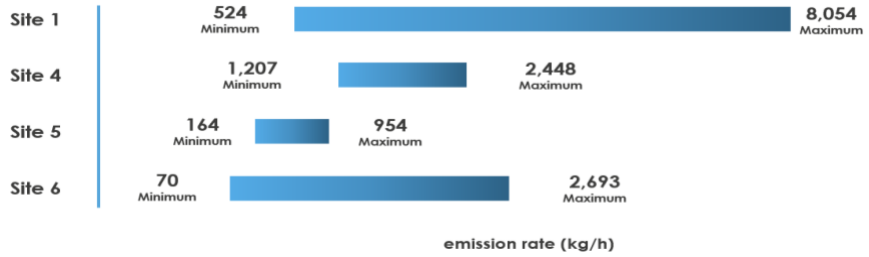
GHGSat made observations at six separate assets every 10 to 15 days,[4] resulting in 175 observations during the nine-month monitoring period (6 detections on average per site). The monitoring sites were selected based on technical criteria (see Appendix 1 for more details), with the aim of identifying facilities with a higher likelihood of methane emissions and thus stronger mitigation impact.

About 20% of the observations confirmed the presence of a methane source above the minimum detection threshold of 100 kg CH4/hour (Figure 1). **At two of the monitored assets, no emission sources above the threshold were observed**.

However, **volumes of methane above the threshold emissions were detected on the four other monitored assets**. The average emission rate observed at the six areas of interest was almost 1,500 kg CH4/hour. If the plume continued unabated for just that one hour, the emissions would be equivalent to the hourly energy use of 43,000 US homes [5]. This **means there is important potential for methane mitigation from single sources**. It also confirms the need for prompt engagement with operators to make sure the source of emissions is known, and to encourage local operators to take steps to eliminate or reduce those emissions.

Around 40% of the detected plumes had emission rates under 500 kg CH4/hour. Two plumes, however, contributed to more than 25% of the total detected emissions[6].

Figure 1: Range of emission rates observed per monitored site



It is important to note that monitored sites covered significant areas (12x12 km) and included a number of facilities with possible methane emission sources, which may belong to different operators.

The number of the plumes detected at each of the monitored sites, presented in Figure 1, suggests that these facilities have a variety of emission sources. Some of the plumes detected at assets 1 and 6 are likely to be consistent or recurring, observed over several consecutive months from the same emission source. Plumes at assets 4 and 5 are likely to be isolated events, or events with methane releases with lower frequency (such as from quarterly maintenance)[7]. Figure 2 also indicates that, for some of the assets, multiple emission sources were detected during the same observation (when the value of successful observations per month in brackets is lower than the value of detections in the same period).

Figure 2: Number of plumes detected per month per monitored asset (with number of successful observations per month in brackets)

[4] GHGSat also analysed some of the methane plumes detected through public satellites which are described in the following section.
[5] Assuming global warming potential (GWP) of methane over 100 years of 28, and using EPA Greenhouse Gas Equivalencies Calculator (2022)
[6] Here, no assumption about the duration of the plume was made; the total amount of emissions was estimated based on the one-hour duration of the plume.
[7] Plume observations are not independent and multiple detections at the same asset at different times are included in the analysis.

	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22
Site 1	0 (1)	4 (3)	2 (1)	1 (1)	0 (1)	2 (2)	1 (1)	0 (1)	0 (7)	0 (2)
Site 2	0 (1)	0 (1)	0 (2)	0 (1)	0 (1)	0 (1)	0 (2)	0 (5)	0 (10)	0 (2)
Site 3	0 (0)	0 (0)	0 (1)	0 (2)	0 (3)	0 (1)	0 (1)	0 (4)	0 (8)	0 (5)
Site 4	0 (0)	0 (1)	0 (1)	1 (2)	0 (1)	0 (1)	0 (2)	1 (4)	0 (8)	0 (5)
Site 5	0 (1)	1 (1)	0 (1)	0 (1)	7 (3)	0 (0)	0 (1)	0 (3)	2 (3)	0 (0)
Site 6	0 (0)	0 (0)	3 (2)	2 (1)	1 (1)	2 (1)	2 (2)	0 (3)	1 (4)	3 (1)

Upon successful detection of the emission source, the plume was attributed to a specific oil and gas facility/operators. Overall, more than 85% of the successful methane detections (from both public and GHGSat satellites) were attributed to a specific field and its operators. Within a few days of the satellite detection, information about the emissions was passed on to the operators of the respective assets.

For some operators, follow-up calls with the operations team covered initial capacity building and discussion of detailed technical issues. These conversations further pinpointed the possible sources of methane emissions for planning and action by operators. Observed emission sources included associated gas flaring (uncombusted gas due to flare inefficiency, especially for older installations), direct venting (such as a temporarily unlit flare), and possible maintenance events.

Public satellites

Public satellite data was also leveraged to identify methane plumes across all of Iraq and, despite limitations, the Campaign showed this data could help identify above threshold methane emissions. Many of the plumes observed were challenging to attribute to specific industrial operations (including oil and gas, mining, waste and agriculture), which made identifying the right contact person and the potential methane source difficult. The analysis below addresses only emissions that have been attributed to specific operators, as uncertainty remains high about the source and reliability of the unattributed emissions.

In total, nine plumes detected by public satellites were attributed to specific operators in the O&G industry with an average emission rate of 10,150 kg CH4/hour.

It is challenging to draw meaningful conclusions about the overall scale of emissions detected through the Satellite Monitoring Campaign, due to the uncertainty regarding the duration of the observed emission events. The box below summarizes the key issues.

Box 1 Emission duration

Duration of the plumes observed

Methane plumes in oil and gas activities have a variety of causes and duration and come from different types of emission sources. The source can vary from continuous or regular engineered vents, undetected leaks, or very short duration events, such as a blowdown of pipelines or equipment

Methane emission duration can be extremely variable and cannot be accurately estimated based on infrequent sampling alone. Typically, an evaluation of the cause of the issue with field operators is required to evaluate the duration.

Key learnings

Learning 1: leverage satellite data to focus on facilities with highest methane emissions whilst recognising there is variability in facility methane emissions

The fact that almost 80% of the successful observations did not detect any methane emissions, and that two of the six observed assets saw no detections at all during the nine months of the Monitoring Campaign presents a useful insight into the nature of methane emissions from the monitored facilities. It shows that,

at the selected sites, the number of observable, persistent emission sources is limited. That allowed us to focus further investigation and mitigation efforts on sites where above threshold emissions are present. It should be noted that the six monitored sites represent only a subset of facilities in Iraq and more targeted monitoring is required to make more generalized conclusions for the country as a whole.

It must be emphasized that there may still be methane emission sources that were not captured at the monitored sites, either because emissions are below the detection threshold or due to the periodical nature of satellite observations (especially true for intermittent emission sources, such as, for example, blowdown events).

Learning 2: OGCI member company presence or relations with local operators allowed for effective and prompt reaction on the ground, leading to emission reductions

Direct contact with some of the operators on the ground and an ability to assess operational data from those sites, allowed OGCI member companies to promptly review any information about possible detected plumes and work with local operators on the ground to investigate the possible emission source. One asset operator confirmed that following the detection of a methane anomaly from the satellite and subsequent investigation, it updated its sites' operational process to reduce emissions during operational procedures.

Learning 3: sharing information and capacity building on methane emissions was well received by all local operators

Operators were very receptive to receiving the satellite monitoring data, whether OGCI member company operators, non-operated joint ventures or national oil companies. Many also expressed keen interest in learning more about the satellite technology, key possible sources of emissions, and available mitigation solutions or potential sources of mitigation financing. Satellite monitoring provided important information to operators on the presence and scale of methane emissions since methane monitoring is not a common practice in Iraq. Learning about importance of methane emission mitigation can inform operator decisions on the type or timing of gas capture and utilization solutions; implementation of a selected solution might be accelerated or adjusted to reduce methane emissions. For example, one operator with a continuous source of methane emissions addressed the emission source by rerouting at least part of the gas to a nearby facility for processing and further local use. Interim actions like this can precede a more permanent large-scale solution.

Broader lessons learned

Some of the broader lessons learned are presented below:

- **Local contacts and a long-term relationship with the operators are vital**
  Identifying the appropriate recipients for the information about an observed methane plume is very important for rapid and effective action. Identification of the relevant contact points within the different assets took significant time[8], but once successful, helped build a solid relationship with operators. Network and connection of the OGCI member companies, GHGSat and Carbon Limits with the local industry helped not only identify the right contacts but also create trust and willingness to act on the shared information.
  The need for more in-depth capacity building on methane emission sources, monitoring and mitigation solutions was raised by several operators. Existing materials with relevant information were provided to the companies.

[8] For assets with no existing contacts, it took over three months and outreach to 10+ persons to identify the right contact point.

- **Clarity on data confidentiality**
  The Campaign only disclosed asset-level data to the operators of the facility where the emissions were detected. The purpose of the data was to facilitate capacity building and mitigation action on the methane sources that are observed above the threshold. In the specific local context, this helped build trust with the local stakeholders and direct focus on the impact.
- **Some of the key barriers to mitigation require further work**
  The Campaign presented an opportunity to explore and discuss key barriers to mitigating identified emission sources with the local operators. While some barriers were technical, operators also confirmed the importance of financial barriers. This is particularly relevant for emission sources that require large upfront investment into additional infrastructure.

Costs and benefits of the Campaign

The Campaign in Iraq showcased how satellite detection and quantification technology, combined with in-country technical expertise and outreach capacity, can lead to a more reflective approach to methane emissions mitigation among the local operators.

As satellites are generally able to capture major sources of methane emissions, mitigation of these sources can lead to notable, cost-effective emission reductions.

The costs of a satellite monitoring programme include (1) fixed costs related to purchasing the satellite data and related outreach, communication, capacity-building activities, etc and (2) variable costs related to actual mitigation actions.

Taking the specific case of one of the assets monitored during the Campaign, where the likely emission source was attributed to incomplete combustion from a flare, we assessed that technical solutions to upgrade the flare and eliminate ignition problems can be installed in Iraq on that asset at a cost between 1 and 20 USD/tonne CO_2e[9], with no additional revenues generated from gas savings as the gas will remain flared, subject to the frequency and duration of the methane releases.

The benefits of the Campaign extend beyond the immediate mitigation impact of the reduced methane emissions. Building capacity and a knowledge base among local operators about the key causes of methane leaks and vents, which are part of any normal operations, also contributes to a lasting shift in the approach to operations and decision-making within a company. As highlighted above, companies with access to actionable data are encouraged to review and update their operational practices, which can reduce emissions of methane and volatile organic compounds (VOCs).

Conclusion and next steps

The Campaign will continue through autumn 2023 with three other countries: Algeria, Kazakhstan, and Egypt. Beyond the OGCI Satellite Monitoring Campaign, large opportunities exist for rapid, effective action on methane in the oil and gas sector through a combination of satellite observations at the country and asset level, as well as targeted engagement with the operators, especially those with limited knowledge of the emission sources and mitigation options.

[9] Assuming global warming potential (GWP) of methane over 100 years of 28.

Appendix 1 - Process and Methodology

Satellite monitoring technology

An integrated solution for the monitoring and quantification of methane emissions was used in the Campaign, utilizing a range of satellite technologies with a variety of thresholds, resolutions, and frequencies. Public satellite data provided an overview of observable emission sources across the country, with a higher resolution and detection threshold. GHGSat's own satellite technology was able to capture facility-level emissions at a more granular level with lower detection limit (See Box 2 below for more information about detection thresholds). GHGSat currently operates five satellites to monitor facility-level greenhouse gas emissions around the world. GHGSat's patented technology uses advanced analytics and public data to remotely monitor areas with a high risk of emissions.

Box 2 Emission rate thresholds

Emission rate thresholds

Detection threshold refers to the lowest limit of emissions rate a sensor can reliably detect.

Some satellites can cover a wide area and thus detect multiple emission points across a given region, for example, a production basin (low resolution, high detection threshold). Satellite technology has a proven track record at identifying and quantifying these emissions. Other satellites will have higher resolution and/or lower detection threshold that will allow them to zoom in to see in greater detail the emissions at a given facility. While providing useful insights into facility-level emissions, satellites cannot be used for component-level detection of methane emissions. Other complementary technologies can be applied on the ground to investigate the origin of the specific emission, for example, optical gas imaging.

The detection threshold varies depending on the satellite, ranging from about 100 kg/hr for GHGSat to a few tonnes per hour for public satellites.

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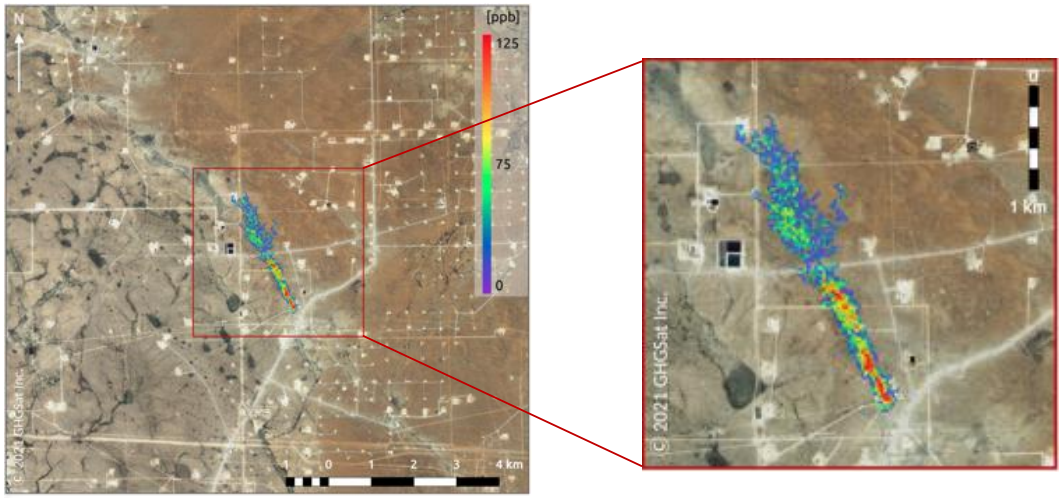
Figure 1: An example of a methane plume detected by one of GHGSat's satellites over the Permian Basin



Source: GHGSat

Dataflow and engagement

The key steps in the process include site selection for monitoring with high-resolution satellites, engagement with the operators and initial capacity building, and finally, technical support to investigate the source of the emissions and support for assessment of mitigation actions.

The selection of fields of interest for the Monitoring Campaign used the criteria and process below:

- A list of oil and gas fields was compiled using available information on past satellite methane observations in Iraq from public satellites, as well as flaring data activity from FlareIntel and the World Bank Global Flaring Data as a proxy for methane emissions.
- Field-specific details were then added to the list, using various sources, such as, Energy Information Administration (EIA), Enverus, etc, which provide information on age of infrastructure, gas/oil ratios, total oil and gas production, expansion plans, operators, etc.
- The results of the preliminary evaluation were used to select a sample of assets from both OGCI member companies and non-members for monitoring. The key selection criteria for prioritization included assets with large production volumes, higher gas/oil ratio, presence of flares and previously detected methane emissions, age of the infrastructure, etc.

The overall focus in selection of assets was on facilities that are more likely to have methane emissions, in order to be able to identify the significant emission sources and take action to achieve rapid mitigation. Thus, the sample is biased towards facilities with higher likelihood of emissions.

Upon selection of the six areas of interest, the operators' contact information was compiled for first engagement to test their interest in receiving actionable data on methane emissions. This proved to be a challenging process for certain assets, where the OGCI member companies, GHGSat and Carbon Limits had no previously established network.

OIL AND GAS CLIMATE INITIATIVE

WHAT IS THE OIL AND GAS CLIMATE INITIATIVE?

The Oil and Gas Climate Initiative is a CEO-led organization bringing together 12 of the largest companies worldwide to lead the oil and gas industry's response to climate change. It aims to accelerate action towards a net zero emissions future consistent with the Paris Agreement. Together, OGCI member companies represent almost 30% of global oil and gas production.

OGCI members set up OGCI Climate Investments to create a US$1 billion-plus fund that invests in companies, technologies and projects that accelerate decarbonization within energy, industry, built environments and transportation. Combined, OGCI members have invested more than US$35 billion in low carbon solutions over the past five years.

OGCI members are Aramco, bp, Chevron, CNPC, Eni, Equinor, ExxonMobil, Occidental, Petrobras, Repsol, Shell and TotalEnergies.

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OUR MEMBER COMPANIES

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