Space-based technologies are providing unprecedented insights into global methane emissions, enabling more accurate monitoring and accountability.

As the oil and gas industry seeks new and better ways of reducing methane emissions from its upstream and midstream facilities,

it's taking full advantage of technologies that allow operators to visualize plumes and concentrations of this invisible greenhouse gas – one that is actually 86 times more potent than carbon dioxide at trapping heat over the first two decades of its release into the atmosphere. From hand-held optical gas imaging cameras to drones outfitted with lasers, operators now have numerous ways to identify and quantify their fugitive emissions.

Another tool that is increasingly being used in this effort is satellite technology, which is already paying dividends – and which has the potential to revolutionize the way we discover and measure methane emissions. Currently there are more than a dozen satellites orbiting the earth that can zoom in on concentrations of methane and other greenhouse gases and send their data back to be processed and analyzed.

Some were developed by non-governmental organizations (NGOs) like Carbon Mapper, whose Tanager-1 satellite was launched in August 2024 and soon began capturing and relaying images of methane being released by so-called super-emitters, the name given to facilities that emit methane at a rate of 100 kilograms per hour or greater. Other satellites with methane detection capabilities have been launched under the auspices of government agencies, such as Italy's PRISMA and the European Space Agency's Sentinel 5P. Now commercial satellite companies and businesses that leverage satellite data have joined the constellation – and they're targeting a very specific group of clients: oil and gas operators themselves. Operators with the resources to avail themselves of this technology may find it to be a highly effective means of identifying methane emissions from their upstream and midstream facilities.

GENERAL CAPACITIES AND LIMITATIONS

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While they may vary in regard to sensor technology and purpose, most methane-detecting satellites share a basic ability to:

- **Scan vast areas in search of emissions.** This includes remote locations and/or sites marked by rough or difficult-to-navigate terrain where accessibility issues can complicate ground-based monitoring efforts. Operators with multiple well sites or other infrastructure spread out over entire basins or regions can benefit from the efficiency and comprehensiveness provided by this level of reach.

- **Monitor the same site with regular frequency**. This capacity allows the satellite to make note of any changes in emissions intensity, be they increases or decreases. It also allows them to detect intermittent emissions, such as those resulting from maintenance events or sporadic leaks.

Satellites whose main purpose is to help governments, large oil and gas companies or NGOs measure methane emissions over large areas, or even entire global regions, are called area flux mappers. They are distinct in general capability and purpose from point source imagers, which are better equipped to identify emissions from individual sources. Though most of the satellites currently in orbit are in the former category, point source technology is improving rapidly. Carbon Mapper's Tanager-1 can zoom in on facilities to identify large emissions events, and the sensors on satellites operated by GHGSat, a commercial enterprise, are similarly capable of detecting and depicting methane emissions in high resolution at the facility level – including emissions coming from gas compressor stations and pipelines – at 25-meter scale.

All satellites have their limitations, however. Certain environmental conditions – including cloud cover, high winds, snowfall and mountainous terrain – can negatively affect their ability to make accurate measurements. If an oil and gas operation has many sources of methane leakage at a single site, if equipment happens to be located near emissions-heavy landfills or livestock facilities, or if operations owned by multiple operators are located near each other, a satellite's sensors may have trouble distinguishing one source from another. Oil and gas operators should take location and environmental factors into consideration before partnering with a commercial satellite company to monitor their methane emissions.

https://eos.com/blog/multispectral-vs-hyperspectral-imaging/

DIFFERENT CAPABILITIES FOR DIFFERENT GOALS

Methane-detecting satellites typically come equipped with one of two different types of sensors. Both work by identifying methane's signature pattern within spectral bands, but they do so in different ways.

- **Multispectral sensors** capture data across a relatively small number of broad spectral bands (typically between three and ten), often including visible and near-infrared wavelengths. Since they operate within just a handful of bands, multispectral sensors tend to be more suitable for the broad-scale monitoring of methane over large areas, making them ideal for area flux mapping. They offer high spatial resolution – the ability of an instrument to zoom in on something and still yield a clear image – and allow for frequent revisits. The smaller number of bands they work with also means that their data is generally easier and faster to process, making them especially valuable when quick, or even real-time, analysis is required.

- **Hyperspectral sensors**, by contrast, capture data across hundreds of much narrower spectral bands. This allows them to provide extremely precise measurements, making them more suitable for the identification of small leaks, including those from point sources inside oil and gas facilities or along pipelines. Hyperspectral sensors typically have lower spatial resolution and revisiting capability than their multispectral counterparts, making them less effective for large-scale mapping or for monitoring changes in methane concentration over time. Their high degree of precision can also make data analysis more complex, resource-intensive and costly.

While most satellites utilize one of these spectrometers, alternatives are emerging. Satellites operated by GHGSat, for example, utilize a patented variant of a Fabry-Perot interferometer – invented in 1899 – to identify methane's chemical fingerprint.

Advances in artificial intelligence (AI) have the potential to revolutionize the way we analyze and process the methane-emissions data collected from satellites. In fact, that revolution has already begun. Massive troves of satellite data are increasingly being complemented by AI models developed by companies like Satelytics and Orbio Earth, who are able to reconcile these datasets with other, earthbound datasets to come up with fully integrated and highly accurate emissions reports – often within a matter of hours – that can then be sold to these companies' operator and energy investor clients. Other developments suggest that AI-enhanced satellite detection could soon end the capacity tradeoff between multispectral and hyperspectral sensors by filling in the gaps in coverage, spatial resolution, revisit frequency and detection accuracy that are often found in one methodology or the other.

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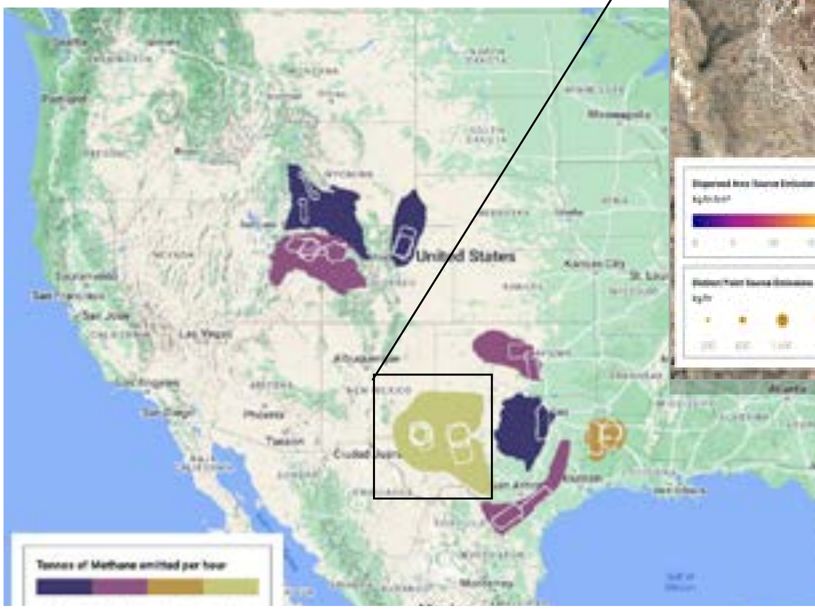

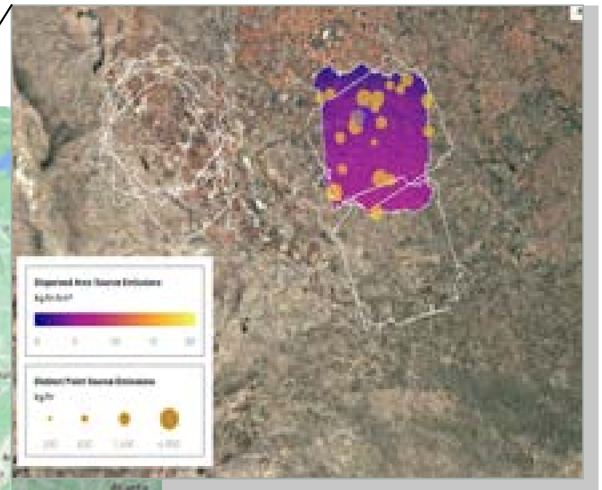

CONSIDERATIONS FOR OIL AND GAS OPERATORS

In a relatively short period of time, satellites have already made measuring methane emissions from oil and gas operations easier, faster and more accurate. Operators have multiple incentives to investigate this technology and to explore how it might be used to help them reduce emissions. Methane that is saved is methane that can potentially be sold in the marketplace. Regulators may require mitigation efforts and penalize operators who don't meet mandated targets. Methane reduction may also play a role in maintaining a company's social license to operate, and in addressing pressure from investors who see it as integral to meeting environmental, social and governance (ESG) requirements.

In addition to those incentives, climate scientists believe that cutting methane emissions from oil and gas operations (alongside landfills and livestock facilities) represents a big, fast and cost-effective opportunity to reduce atmospheric methane concentrations. Satellites are already showing great promise and seem certain to play an increasing role in the full spectrum of methane mitigation solutions. As sensor technology develops further and more methane-detecting satellites enter orbit, they will likely lead to lower costs for "top down" measurements of emissions – which allow for empirical and site-specific measurements of methane – as opposed to the "bottom up" measurements that rely on extrapolative estimates based on emissions factors.

Chubb is dedicated to partnering closely with oil and gas clients to help them identify and implement the most effective tools for reducing methane – including the newest ones, such as satellite technology. The Chubb Methane Resource Hub is a valuable digital resource for discovering more about the different strategies being pursued towards this goal. Another valuable resource is our team of specialized risk engineers, many of whom have decades of experience in the oil and gas sector. Learn more about our Natural Resources practice, or get in touch with us, here.