Gulf of Mexico Health and Air Quality

Utilizing NASA Earth Observations to Identify Potential Methane Sources for Improved Monitoring of Offshore Oil & Gas Activity in the Gulf of Mexico

Project Team

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Project Overview

Project Synopsis:
A third of methane emissions come from oil and gas activity, but it is particularly difficult to monitor these emissions offshore. The goal of this project is to map out existing offshore oil and gas infrastructure in the Gulf of Mexico and identify potential sources of methane for directed future investigation using satellite imagery. The results will support partners at the Bureau of Safety and Environmental Enforcement (BSEE), the Bureau of Ocean Energy Management (BOEM), and SkyTruth to monitor offshore oil and gas activity, specifically the flaring and venting of associated gas.

Abstract:
The extraction, production, and transportation of oil and gas is a leading contributor to anthropogenic methane emissions via activities such as flaring and venting. The Bureau of Ocean and Energy Management (BOEM) has air quality jurisdiction offshore in the Gulf of Mexico and drafts regulations for criteria pollutants, while the Bureau of Safety and Environmental Enforcement (BSEE) enforces these regulations. Additionally, the non-profit organization SkyTruth monitors natural resources, including methane. BOEM, BSEE, and SkyTruth have partnered with NASA DEVELOP to use Earth observations to identify potential offshore methane sources in the Gulf of Mexico and to validate reported flaring activity. This information will allow BOEM and BSEE to make informed regulations regarding air pollution. Here, we cross-referenced BOEM infrastructure data with Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Radiometer Suite (VIIRS) Nightfire data to validate operator-reported flaring. Sentinel-5p TROPOspheric Monitoring Instrument (TROPOMI) pollutant concentrations were used to validate VIIRS-detected flaring outside of the Gulf of Mexico where operator-reported data is unavailable. Using these methods, we identified the locations of offshore oil and gas infrastructure with known episodic flaring and venting in 2017 in the Gulf of Mexico, as well as offshore of South America and West Africa in 2021. Drawing upon retrieval methods used to detect onshore methane emissions, we proposed an analogous method utilizing sunglint to illuminate methane plumes over the ocean using Sentinel-2 Multispectral Imager (MSI) imagery. We detected two potential methane plumes – one at the Constitution complex in the Gulf of Mexico in July 2017 and one off the Coast of Lagos, West Africa, in July 2021.

Key Terms:
flaring, venting, VIIRS Nightfire, sunglint, NO_2:SO_2 ratios

National Application Area Addressed: Health & Air Quality
Study Location: US Federal Waters in the Gulf of Mexico, Caribbean Coast of South America, Southwest Coast of Africa
Study Period: 2017, 2020-2021

Community Concerns:

- There is currently a lack of in situ air quality sensors on the ocean's surface, making ground-truthing impossible and regulation of oil and gas emissions challenging. The partner agencies currently rely solely on operator-reported inventory estimates of venting, the direct release of non-combusted natural gas, and flaring, the controlled burning of natural gas.
- Due to weather patterns, oil and gas emissions in the gulf impact air quality of nearby communities onshore.
- Both venting and flaring processes expel natural gas, typically to reduce risks like explosions. It can often be costly to transport or dispose of natural gas in other ways. Natural gas can produce air pollutant byproducts which can cause respiratory and other health issues.
- While flaring and venting from offshore oil and gas facilities are both harmful, controlled flaring is not as detrimental to the atmosphere because the byproducts of combusted natural gas – namely carbon dioxide – have lower global warming potentials than non-combusted methane.
- Presently, the partner agencies lack the ability to validate monthly emissions estimates and activities reported by operators in The Gulf. This lack of oversight could result in increased pollution and greenhouse gas emission from offshore operators.

Project Objectives:

- Identify infrastructure in the Gulf of Mexico and supplementary areas with persistent flaring and venting activity
- Select locations to serve as candidates for detecting methane plumes in sunglint-configured imagery
- Compare bottom-up emission estimate inventories alongside remotely sensed data

Partner Overview

Partner Organizations:

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement	Jay Cho, Program Manager, Engineer; Ramona Sanders, Senior Environmental Stewardship Coordinator; Jarvis B. Abbott, Safety Performance Enhanced by Analytical Review (SPEAR) Program Coordinator	End User	No
U.S. Department of the Interior, Bureau of Ocean Energy Management	Holli D. Ensz, Physical Scientist; Cholena Ren, Physical Scientist; Thomas Kilpatrick, Ocean and Atmospheric Scientist	End User	No
SkyTruth	John Amos, President	Collaborator	Yes

Decision-Making Practices & Policies:

BSEE enforces BOEM's air quality rules in addition to regulating venting and flaring. BSEE currently uses infrared cameras to identify fugitive or accidentally released methane during inspections, but they cannot determine the volume of the plume nor for how long methane was released. Under the Code of Federal Regulations Title 30, Part 250, the BSEE Regional Supervisor must provide operators with approval to flare or vent natural gas except in certain situations, including emergencies, operational testing, and equipment failure. In such exceptional circumstances, regulation limits the duration and volume of natural gas release. In addition, offshore facilities that process a daily average of over 2000 barrels of oil must install flare or vent meters with 5 percent accuracy. Facilities that produce fewer barrels do not typically require meters, however, the operator must report incidents of flaring and venting on a lease or unit basis. BOEM is primarily concerned with offshore air quality rulemaking, and they conduct an emissions inventory every three years which includes estimates for greenhouse gases like carbon dioxide and methane. BOEM does not yet have the authority to regulate these gases due to a lack of existing performance standards, but the agency has indicated that they may gain this authority in the future as they improve their methane monitoring capacity through remote sensing.

Earth Observations & End Products Overview

Earth Observations:

Platform & Sensor	Parameters	Use
Suomi NPP VIIRS	Radiative heat and temperature	VIIRS Nightfire data were used to map sustained flaring in several hotspots of oil and gas production around the world. These flaring data were then used to identify potential methane emission sources.
Sentinel-2 MSI	Surface reflectance	Sentinel-2 imagery with sunglint was used to identify methane plumes emitted from offshore oil and gas infrastructure through venting or incomplete flaring.
Sentinel-5P TROPOMI	NO_2 tropospheric column concentration SO_2 tropospheric column concentration	TROPOMI NO_2 and SO_2 emissions data were used to identify where NO_2/SO_2 ratios are low, which can validate VIIRS-detected flares where operator-reported data is unavailable, as well as identifying flaring events missed by VIIRS.

Ancillary Datasets:

- BOEM Outer Continental Shelf Air Quality System (OCS AQS) – Access BOEM's database of operator-reported emissions estimates for methane and other air pollutants from oil and gas operations in the Gulf of Mexico.
- BOEM Geographic Mapping Data Center – Download and visualize locations of active leases, platforms, and pipelines from oil and gas operations in the Gulf of Mexico.

Software & Scripting:

- QGIS 3.16.16 – Visualize distribution of infrastructure and instances of flaring
- Google Earth Engine Javascript API – Identify satellite imagery containing sunglint
- Python 3.9.7 – Visualize flaring and venting data across various Gulf of Mexico facilities throughout 2017, cross validate VIIRS flaring and OCS AQS reported flared volume

End Products:

End Product	Earth Observations Used	Partner Benefit & Use	Software Release Category

Potential Methane Plume Images	Sentinel-2 MSI	These images portray identified potential methane plumes which will be confirmed, mapped, and quantified in the second term. End users will use this information to focus monitoring efforts and resources in identified locations to ensure compliance with flaring and venting regulations.	N/A
Offshore Flaring and Venting Maps	Suomi-NPP VIIRS	These maps portray gas flaring hotspots alongside BOEM infrastructure locations. End users can use these data to validate reported flaring duration to ensure compliance with regulations. Additionally, they can identify areas to allocate resources for enhanced monitoring.	N/A
Flaring Cross Validation Maps; VIIRS and TROPOMI	Suomi-NPP VIIRS Sentinel-5P TROPOMI	The graphics compare VIIRS flaring radiant heat observations with TROPOMI NO_2/SO_2 measurements in both supplementary AOIs. End users can use this as an example of sunglint-configured methane retrieval in AOI where sunglint is more readily available.	N/A
Gulf of Mexico Reported Flare and Vent Volume Comparison Graphics	N/A	These maps provide our partners with the ability to selectively monitor facilities that constitute as having abnormally high flare or vent volumes. This will help partners identify flaring and venting trends and identify possible malfunctions or mismanagement leading to excess venting.	N/A

Product Benefit to End User:

The DEVELOP team produced maps within the Gulf of Mexico that detail sites of persistent flaring near oil facilities between January 2019 - December 2021. By associating each VIIRS flaring event with a platform within an 800-meter radius, BOEM can determine which facilities have unreported flaring activity. With BOEM's reports currently supported by secondary data, BOEM can utilize these findings to begin regulating methane emissions in the near future. By overlaying NO_2/SO_2 ratios over VIIRS-detected flares in our Caribbean and West African AOI, our team can validate VIIRS observations outside of the Gulf, and more robustly demonstrate a proof of concept for sunglint-configured methane retrieval. Unlike BOEM, BSEE does perform on-site inspections to identify fugitive emissions, but these data do not portray the relationship between the length of time and given emissions. The monthly oil infrastructure maps that identify flaring

activity will enable BSEE to accurately target emission reduction and potentially utilize satellite data for methane monitoring to inform responses for future environmental events. Since BSEE currently relies on BOEM's emission estimates to perform annual inspections, the results of our project directly improve how BSEE approaches its on-site compliance reviews.

Project Continuation Plan:

Term II will expand our Gulf of Mexico validation analysis to BOEM's newly released 2021 inventory. Sunglint analysis will be extended to Precursore Iperspettrale della Missione Applicativa (PRISMA), Landsat 8 Operational Land Imager (OLI), and Landsat 9 OLI-2. To efficiently select favorable scenes for sunglint retrievals, the second term will need to improve the current script's cloud masking and glint detection methods. Improving this workflow will allow the partners to efficiently detect more plume images, thus solidifying the merit of sunglint-configured methane retrievals over the ocean. By fleshing out both the limitations and potential of our approach, the second term will provide our partners with methods to validate operator reported venting by quantifying offshore contributions to the global methane budget. Additionally, the second term will apply wind rotations to TROPOMI ratios to boost flaring signals and identify additional active OG facilities to target methane retrievals. Lastly, the second term will conduct investigations of the facilities showing probable plumes. This will shed light on the context of the methane plume – is it an intermittent venting occurrence, is it due to some malfunction, what are the gas storage and transportation infrastructure present at this facility, how much oil does this company produce vs. vent?

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