NASA DEVELOP National Program
2022 Spring Project Proposal

California – JPL
Gulf of Mexico Health & 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 Overview

Project Synopsis: A third of methane emissions come from oil and gas activity, but it is particularly difficult to monitor these emissions offshore. There are satellite missions planned to target methane emissions that could accomplish this monitoring; however, existing Earth observations (EOs) can capture methane plumes where there is a bright background, or sunglint is present. This project will be the first phase of a two-term project to map methane plumes with sunglint-configured imagery. This term will map offshore oil infrastructure, gas flaring hotspots, and potential methane emissions sources using Suomi NPP VIIRS and Sentinel-1 C-SAR data in the Gulf of Mexico. The goal is to identify potential offshore methane sources for directed future investigation with sunglint-configured imagery to help partners at the Bureau of Safety and Environmental Enforcement (BSEE), Bureau of Ocean Energy Management (BOEM), and SkyTruth monitor offshore oil and gas activity, including identifying abandoned wells, continuous leaks, non-compliant sources, and wells that have intermittent flaring.

Study Location: Gulf of Mexico, TX, LA, MS, AL & FL
Study Period: January 2019 – December 2021

Advisor(s): Daniel Cusworth (University of Arizona), Benjamin Holt (NASA Jet Propulsion Laboratory, California Institute of Technology)

Source of Project Idea: The idea for this project originated with Daniel Cusworth, who was interested in a DEVELOP project using a multi-satellite approach for methane emissions mapping. There are missions planned to capture methane emissions at a finer spatiotemporal resolution, but this project would explore how we could combine the benefits of different existing satellite data (i.e. spatial resolution, direct methane estimates, etc.) for methane monitoring. While considering potential end user partners, the idea to focus on methane emissions offshore was proposed with BSEE and BOEM identified as end users that would be interested in this project. Additionally, SkyTruth was identified as a partner to support the project. Partners at SkyTruth suggested cross-referencing VIIRS flaring data and Sentinel-1 derived offshore oil infrastructure to identify locations for targeted methane plume mapping, which will be the main end product from the first term of this project.

Actionable Decision: BOEM has air quality jurisdiction offshore in the Gulf of Mexico and draft regulations for criteria pollutants. They may be drafting methane reduction rules this year, so results identifying methane sources will help them target their rulemaking. In addition to enforcing rules set by BOEM, BSEE has conservation rules concerning venting and flaring activity in the Gulf of Mexico. End products from this first term would provide a top-down approach to monitoring venting and flaring activity.

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, 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

End User Overview

End User's Current Decision-Making Process & Capacity to use Earth Observations: BOEM is involved in air quality rulemaking offshore, which BSEE enforces in addition to regulating venting and flaring activity. BOEM conducts an emission inventory every three years, which BSEE uses to support its annual compliance reviews and inspections. Additionally, while this emission inventory includes estimates for greenhouse gasses such as methane and carbon dioxide, the historical statutory authority to regulate greenhouse gasses is limited and as such there are no performance standards for them. BSEE uses infrared cameras to identify fugitive emissions during inspections, but this data does not indicate the length of time and pollution contribution associated with these emissions. Otherwise, BSEE and BOEM do not use NASA Earth observations and rely on emissions inventories and the EPA's greenhouse gas reporting program to enforce their regulations. This project would build their capacity to use satellite imagery for more frequent emissions monitoring and compliance review concerning venting and flaring activity.

Partner Interest/Demand: Partners at BSEE and BOEM were approached with the project idea and showed great interest in the project, with 25-30 individuals joining the first meeting. They have previously collaborated with NASA projects to map oil slicks and have spoken with Carbon Mapper about collaborating. SkyTruth is interested in providing advising and will be joining advising meetings with Dan Cusworth.

Partner Communications: We have met with BSEE and BOEM once before the term to discuss the project, gauge their interest, and discuss potential end products. There is a lot of interest from these organizations, but only the names listed in the proposal need to be included in regularly scheduled meetings and correspondence. We have met with Dan Cusworth and SkyTruth twice before the term to discuss datasets and methods to use. The team will meet with advisors (Dan and SkyTruth) on a weekly basis and partners (BSEE and BOEM) on a bi-weekly basis. Only the first advising and first partner meetings have been scheduled.

Partner Experience: BSEE and BOEM regularly use GIS, are familiar with remote sensing, and have collaborated on past projects with NASA to incorporate Earth observations.
SkyTruth regularly uses Earth observations and develops remote sensing methods to monitor natural resources. They typically use Python or the Google Earth Engine JavaScript API when coding.

Earth Observations Overview

Earth Observations:

Platform & Sensor	Parameter(s)	Use

Suomi NPP VIIRS	Flaring volume	VIIRS Nightfire data was used by SkyTruth to map sustained flaring at about 115 degrees Celsius. This flaring data will be used to identify potential methane emissions sources.
Sentinel-1 C-SAR	Offshore oil infrastructure	Sentinel-1 C-SAR was used by SkyTruth to identify areas with offshore oil infrastructure in 2020. This infrastructure data will be used to identify potential methane emissions sources.

Ancillary Datasets:

- Earth Observation Group Annual Flaring Volume Estimate Map – identify areas of high methane flaring where offshore oil & gas activity may be occurring

Data & Modeling Insights: While the Sentinel-1 data will be useful for identifying infrastructure, the most reliable dataset for offshore oil infrastructure within U.S. waters will come directly from BOEM's website. However, this can be used to identify sources in international waters and to monitor sites known to have oil leaks for comparison for sites within U.S. waters. The VIIRS flaring data produced by SkyTruth has a temperature filter to remove fires unrelated to oil and gas. However, there should not be any fire activity in the GOM and the team should consider removing this filter.

Decision Support Tool & End Product Overview

End Products:

End Product	Partner Use	Datasets & Analyses	Software Release Category
Potential Methane Sources Map	This map will map potential methane plume sources by identifying oil infrastructure where gas flaring is concentrated. End users can focus monitoring efforts and resources in these locations to ensure compliance.	This map will be produced by cross referencing oil infrastructure data produced using Sentinel-1 C-SAR imagery and gas flaring hotspots produced using VIIRS nightfire data.	N/A
Offshore Oil Infrastructure Map	This map will identify oil infrastructure each year. Mapping infrastructure each year will allow end-users to track active and inactive oil & gas activity. This will enable them to verify their records and ensure compliance.	This map will rely on Sentinel-1 C-SAR data, replicating methods from SkyTruth to create maps for 2019 and 2021.	N/A
Offshore Flaring Hotspots	This map will identify gas flaring hotspots **over time**. End users can use this data to validate reported flaring and venting duration and volumes to ensure compliance with regulations. Additionally, they can identify areas to allocate resources for enhanced monitoring.	This map will compile gas flaring data from Skytruth produced using VIIRS data to map concentrations of gas flaring annually.	N/A

Priorities: The first priority should be evaluating the Sentinel-1 data, exploring the VIIRS data, and cross-referencing the two to identify targets for targeted methane plume mapping. If these tasks are completed, the team can begin evaluating data availability for scenes where sunglint is present in these target locations.

Project Timeline & Previous Related Work

Project Timeline: 2 Terms: 2022 Spring to 2022 Summer

Multi-Term Objectives:

- **Term 1 (Proposed Term):** 2022 Spring (JPL) – Gulf of Mexico Health & Air Quality
    - This term will cross-reference oil infrastructure data and flaring data to identify potential methane sources. These sources will be areas where there is known oil infrastructure and gas flaring hotspots present. With these results, the second term can map methane emissions using sunglint-configured imagery in these locations. Time permitting, the first term can begin to evaluate data coverage within the potential sources of imagery where sunglint is present. The team will meet with partners bi-weekly and email correspondence as needed. The team will handoff results of this term during the final week of the term.
- **Term 2:** 2022 Summer (JPL) – Gulf of Mexico Health& Air Quality II
    - The second term will take potential sources identified in the first term and map methane plumes using Sentinel-2 MSI, Landsat 8 OLI, and PRISMA data where sunglint is present. The team will continue meeting with partners on a bi-weekly basis with email correspondence as needed. The team will host a soft handoff during Week 8 of the term to review end products and receive feedback before a final handoff during Week 10. During the final handoff, the team will review final results, methods, answer questions, and go over the final handoff package for partners.

Related to other NASA work? Carbon Mapper

References:

Cusworth, D.H., Jacob, D.J., Varon, D.J., Miller, C.C., Liu, X., Chance, K., et al. (2019). Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space. *Atmospheric Measurement Techniques, 12,* 5655- 5668. doi: 10.5194/amt-12-5655-2019.

Ayasse, A.K., Thorpe, A.K., Roberts, D.A., Funk, C.C., Dennison, P.E., Frankenberg, C., et al. (2018). Evaluating the effects of surface properties on methane retrievals using a synthetic airborne visible/infrared imaging spectrometer next generation (AVIRIS-NG) image. *Remote Sensing of Environment, 215*, 386-397. doi: 10.1016/j.rse.2018.06.018.

Key Papers & Resources to Read:

- SkyTruth, Flaring, https://skytruth.org/flaring/
- BOEM, Oil & Gas Mapping and Data, https://www.boem.gov/oil-gas-energy/mapping-and-data
- US Department of Energy Office of Fossil Energy, U.S. Federal Offshore Gas Flaring and Venting Regulations, https://www.energy.gov/sites/prod/files/2020/06/f75/U.S.%20Federal%20Offshore%20Gas%20Flaring%20and%20Venting%20Regulations%20Fact%20Sheet.pdf