

CARBON MAPPER

Dr. Alana Ayasse March 11th, 2022 FLUXNET Early Career Seminar



OUTLINE

- Carbon Mapper Inc Overview
- Current Airborne Campaign Data and Insights
 - Methods and Data
 - Past campaign insights
 - Ongoing work
- Carbon Mapper Satellite Program





QUICK FACTS

- Carbon Mapper is a 501c3 nonprofit
- Our Satellite Program is being developed through a unique public-private partnership
- Launching two demonstration satellites in 2023
- Expanding constellation in 2025 with daily/weekly monitoring
- Currently conducting aerial surveys in key regions
- Exploring potential use for land/ocean data products.



OUR MISSION

Fill gaps in the emerging global ecosystem of CH₄ and CO₂ monitoring systems by delivering data that is **precise**, **timely**, and **accessible** to empower science-based decision making and **action**.





WHAT WE DO

- 1. Detect CH₄ and CO₂ emissions using visibleinfrared imaging spectrometers on satellites and aircraft
 - Currently conducting airborne mapping across select regions
 - Setting the stage for satellite constellation deployment
- 2. Provide decision-makers with open access to data
 - Open online data portal provides access to airborne data products

3. Distill insights to drive mitigation action

- Range from leak detection, to direct engagement on specific regional opportunities
- Designed to drive immediate action and inform science-based decisions





AIRBORN PROGRAM

2016-2021 Airborne Data available at <u>carbonmapperdata.org</u>





Hazardous Plume Mitigated in Colorado: During surveys in Denver-Julesburg basin we detected multiple leaks that resulted in regulatory and mitigation action. In one case (*left*), we flagged a large methane plume in a commercial and residential area near a mall outside of Denver associated with an oil well unloading. We notified collaborating state agencies who quickly confirmed the leak and led to immediate enforcement action and repair.

Trends in the Permian Basin: Following our latest surveys of the Permian Basin, we now have 3 years of data and can assess long-term trends. We've identified a small number of high-emitting facilities that have been leaking non-stop for 2-3 <u>years</u>, and are working with EDF (who support the survey) to complete analysis and publish on their <u>PermianMAP</u>.

Identifying Gas, Coal and Landfill Methane Sources in Pennsylvania: We surveyed sections of the Marcellus Shale to assess methane gas and coal production (*right*) as well as selected municipal landfills. The PA Department of Environmental Protection is using our data to notify and follow up with individual facility operators, some of whom are taking mitigation actions.

Assessing Long-Term





website and our Data portal.

Demonstrating New Techniques in Louisiana/Gulf of

Mexico: In April and October we conducted surveys of LA and the Gulf of Mexico to test a technique called "ocean glint mode" intended to allow the Carbon Mapper satellites to track methane emissions from a diverse range of offshore oil and gas platforms and LNG tanker ships at sea. (*Right: An oil and gas platform in the Gulf of Mexico where methane emissions have been observed consistently in April and October. Average emissions for this site are estimated to be 1300 \pm 300 \text{ kgCH4/hr.})*





METHODS





Figure 3. (a) AVIRIS-NG measured and modeled radiance for one image pixel within the CH₄ plume used for the CH₄ retrieval (see Figure 2b). (b) The residual is plotted with 1 σ standard deviation boundary calculated from residuals for the entire scene.

Wavelength (nm)



Meas.

Figure 7. (a) AVIRIS-NG measured and modeled radiance for one image pixel within the CO₂ plume for the CO₂ retrieval (see Figure 6b). (b) The residual is plotted with 1 σ standard deviation boundary calculated from residuals for the entire scene.



DATA

- Instantaneous emissions rates and locations for point source methane plumes over 10 kg/hr over a wide area.
- Images of the instantaneous
 methane plume







Summary of methane emissions for each surveyed basin

Airborne surveys of US: super-emitters contribute 20-60% of regional total emissions





Cusworth et al., 2022; https://eartharxiv.org/repository/view/3084/



Methane plume mapping of offshore oil and gas Infrastructure





Dozens of "super-emitting" oil and gas facilities leaked methane pollution in Permian Basin for years on end

Three years of independent airborne surveys reveal near-term opportunities to meet domestic and international methane reduction targets

 30 facilities—including pipelines, well pads, compressor stations and processing facilities—persistently emitted large volumes of methane over multiple years, and repairing those leaks could immediately reduce 100,000 metric tons of methane per year.

https://www.edf.org/media/dozens-super-emitting-oil-and-gasfacilities-leaked-methane-pollution-permian-basin-years-end





ON GOING AIRBORNE WORK

- Mitigation experiments in partnership with California Air Resource Board (CARB)
- Controlled release experiments with Sanford University (figure right)
- Landfill surveys throughout CONUS and Canada
- Continued mapping of oil and gas basins
- CO₂ Analysis



Controlled release experiment 2021



CURRENT STATE-OF-THE-ART CH₄ REMOTE SENSING





- Satellite: S-5P/TROPOMI
- Pixel size: 7 km
- Global land coverage
- Limited by clouds
- Good for regional inversions
- Point-source detection: ~15,000 kgCH4/hr



TROPOMI XCH4 measurements. A. Map of eastern N America showing a blowout region, B. during, C. before, and D. after the blowout event.



CURRENT STATE-OF-THE-ART CH₄ REMOTE SENSING



S5P/TROMPOMI flux map and GAO point source obs



Facility Scale:

- Aircraft: AVIRIS-NG & GAO
 - Pixel size: 3—9m •
 - Point source detection limit: 3—15 kgCH₄/hr
 - Rapid regional surveys
- Satellite: PRISMA, S2, GHGSat
 - Point source detection: 100-1000 kgCH₄/hr

Carbon Mapper Satellites: Unprecedented Completeness

Airborne coverage: 2,500-14,000 km²/day/aircraft Satellite coverage: 93,000-315,000 km²/day/satellite











30% of global O&G production is offshore



CARBON MAPPER



Satellite parameters	Values
Orbit altitude (km)	400
Orbit type	sun synchronous
Sample interval (days) [full constellation]	1 - 7
Spatial resolution (m)	30
Swath width (km)	18
Area coverage (km2 per day per satellite)	93,000 - 315,000
Spectral range (nm)	400 - 2500
Spectral sampling (nm)	5
SNR @ CH ₄ detection band (medium bright scene)	300 - 600
CH ₄ Minimum Detection Limit ¹ (kg/hr)	50 - 150
CO ₂ Minimum Detection Limit ¹ (kg/hr)	200,000 - 600,000
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¹point source, single-detection; varies with observing mode, wind-speed, surface brightness



CARBON MAPPER

- Public-private partnership
- Launch 2 demonstration satellites in 2023
- Expand constellation in 2025, daily-weekly monitoring
- Monitor 90% of high emitting CH₄ & CO₂ sources globally
- 100% of CH₄ and CO₂ data publicly available from Carbon Mapper portal within 90 days





Backup

