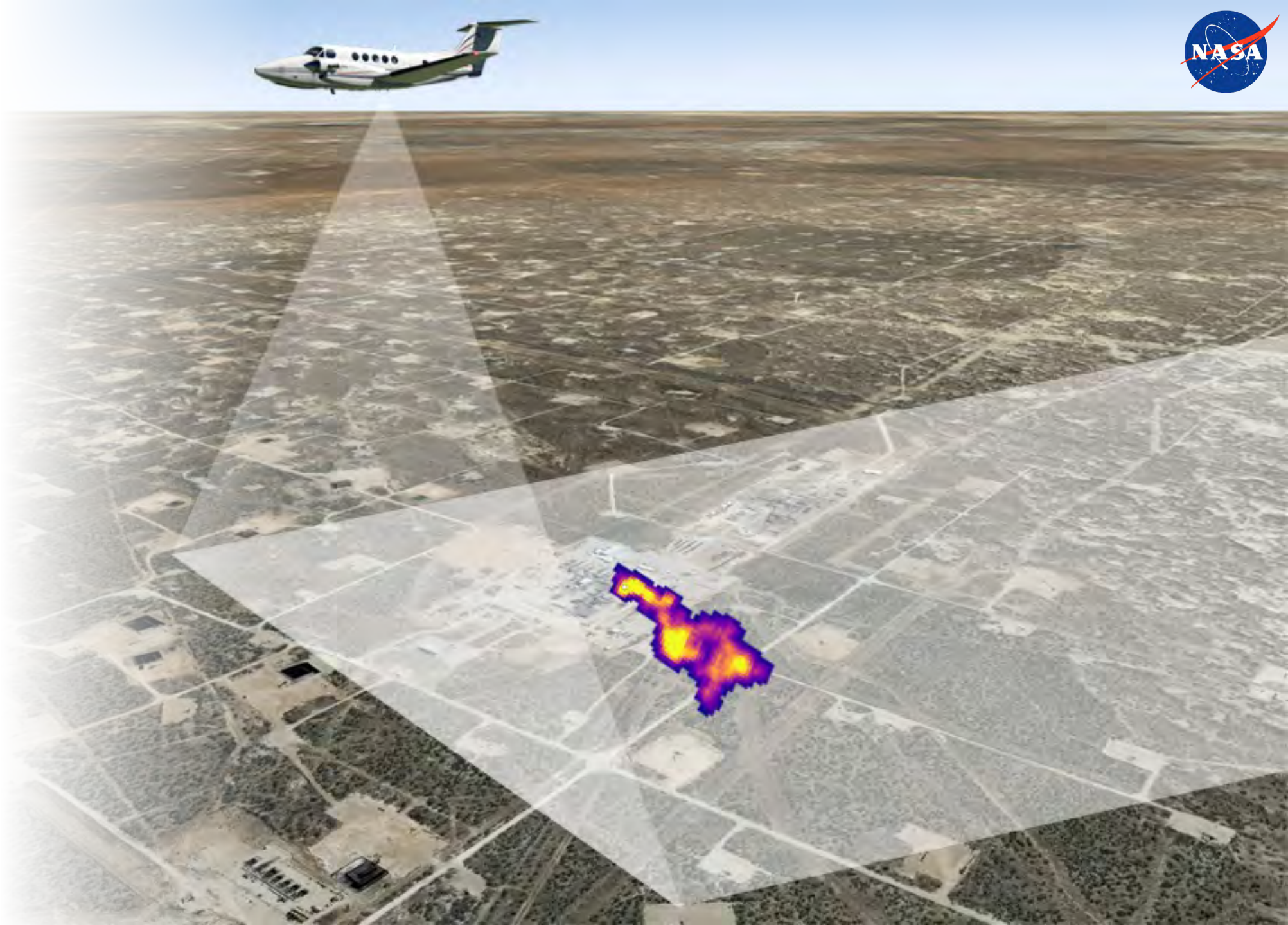
Airborne CH_4 and CO_2 observations using imaging spectrometers



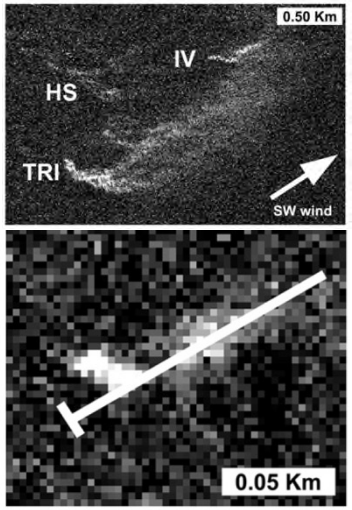
Andrew K. Thorpe[1*], Robert O. Green[1], and AVIRIS/EMIT teams

[1]NASA Jet Propulsion Laboratory, California Institute of Technology

[*]Andrew.K.Thorpe@jpl.nasa.gov

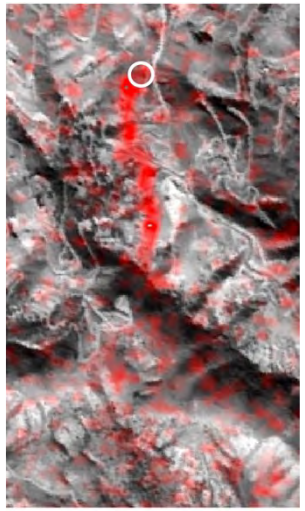
Remote measurement of GHG enhancements using NASA imaging spectrometers has a long track record

Airborne CH_4 observations from AVIRIS, 2008



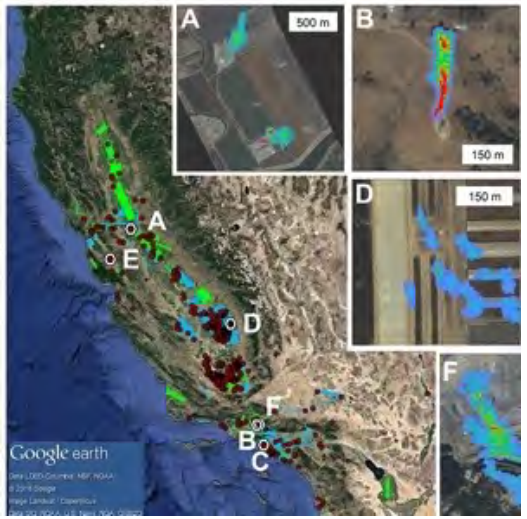
Thorpe et al., 2013

First spaceborne observations from Hyperion, 2016



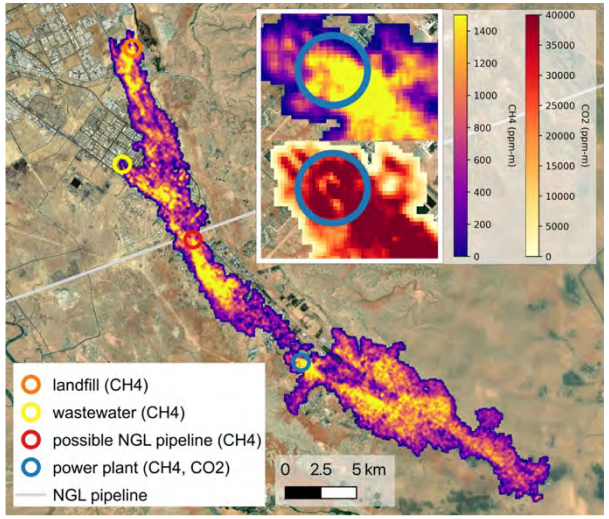
Thompson et al., 2016

Multi-sector methane observations with AVIRIS-NG across California, 2019



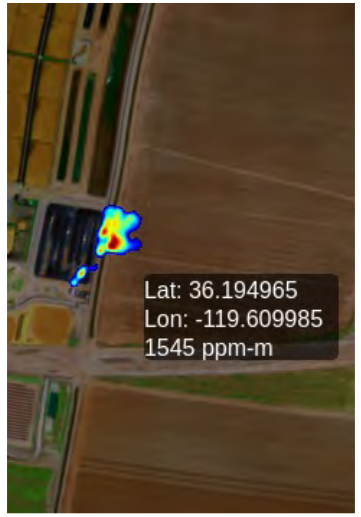
Duren et al., 2019

Observations from EMIT sensor from international space station, starting 2022



Thorpe et al., 2023

AVIRIS-3 CH_4 observations begin in western US, 2023



Coleman et al., in prep.

NASA imaging spectrometers deliver new understanding of GHG emissions

Jet Propulsion Laboratory
California Institute of Technology

AVIRIS-3 2023
AVIRIS-NG* 2013
AVIRIS 2008

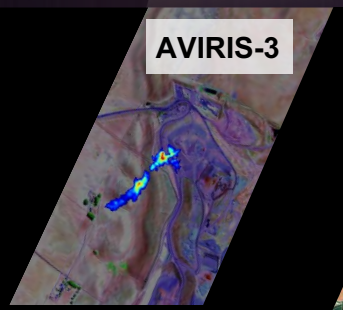
- CH_4, CO_2 point source imager (energy, waste, & agriculture emissions)
- Improved sensitivity relative to EMIT (10s of kg CH_4 hr^{-1})

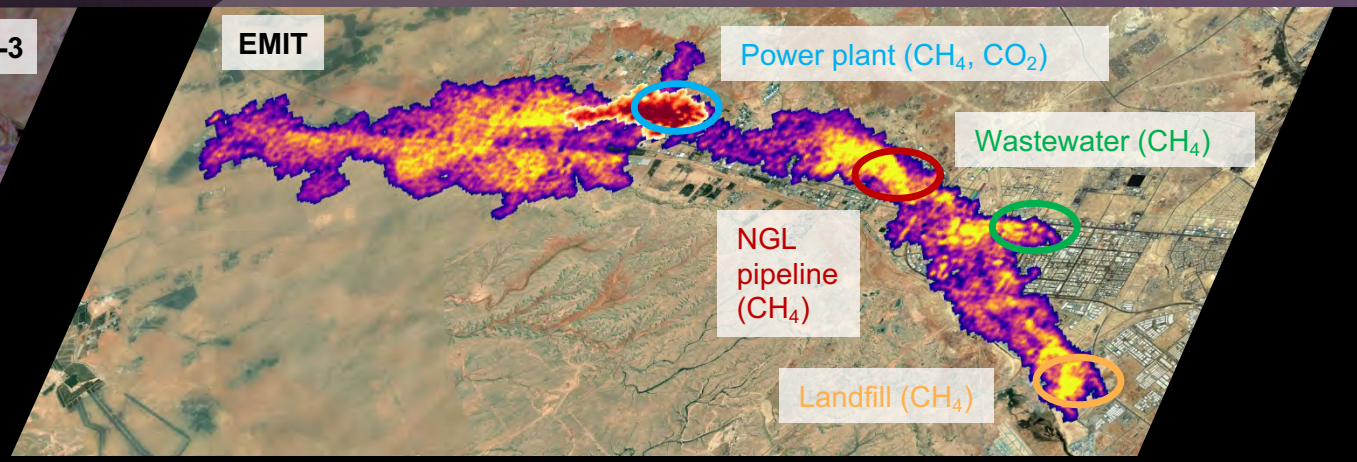
*Global Airborne Observatory (GAO) was built at JPL

EMIT on ISS 2022**

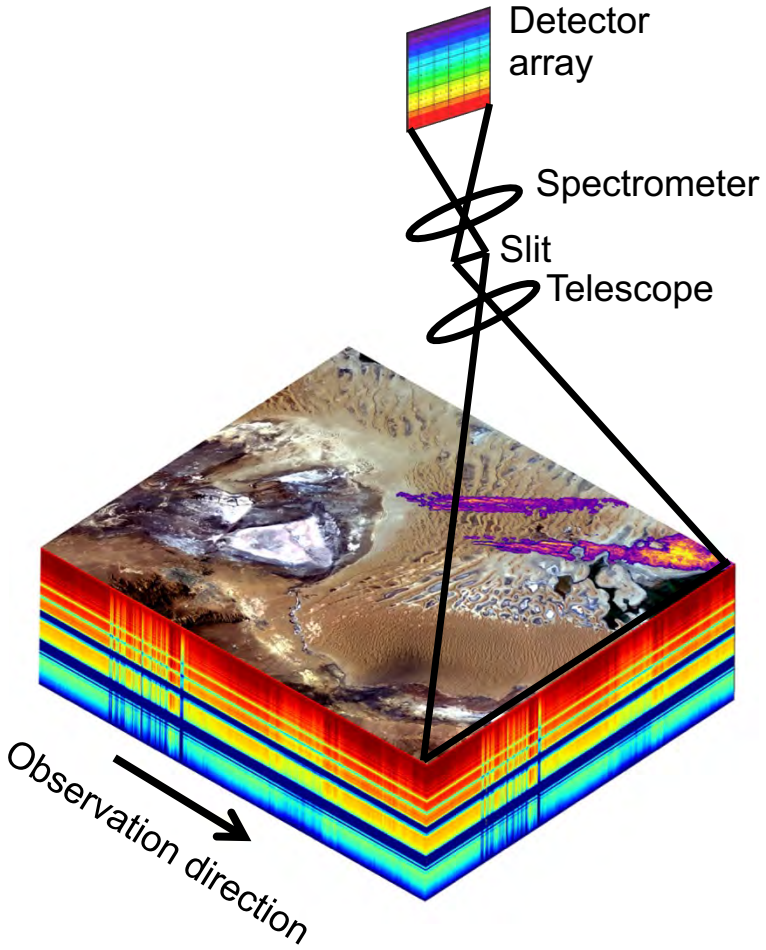
- CH_4, CO_2 point source imager (energy, waste, & agriculture emissions)
- Less sensitive relative to airborne (100s of kg CH_4 hr^{-1})
- Wider coverage

Carbon Mapper Coalition Tanager Satellite utilizes JPL technology and **will have improved sensitivity compared to EMIT

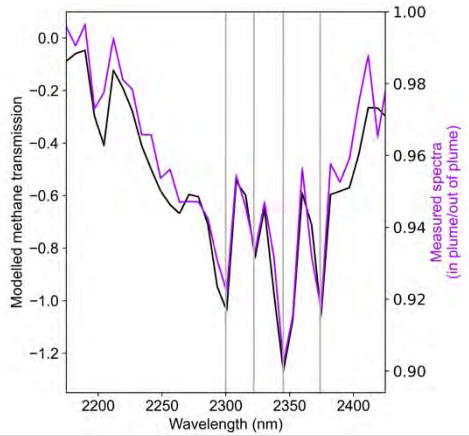




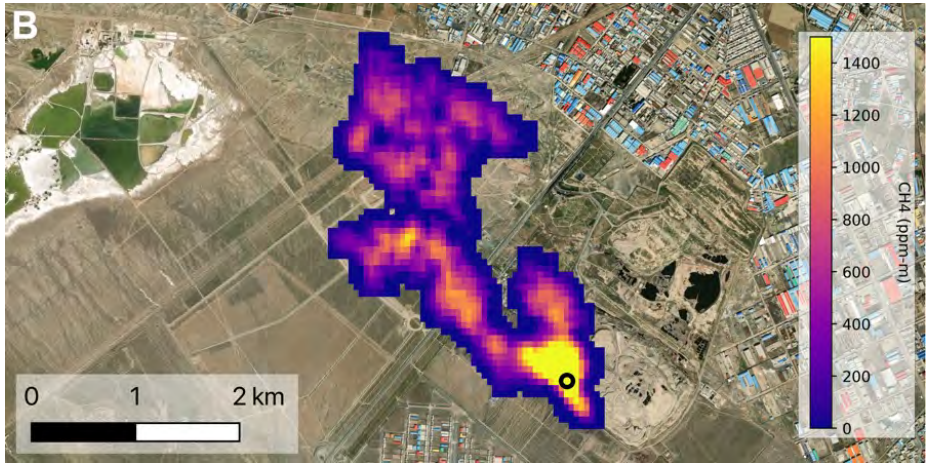
Remote measurement of CH_4 and CO_2 spectral fingerprints



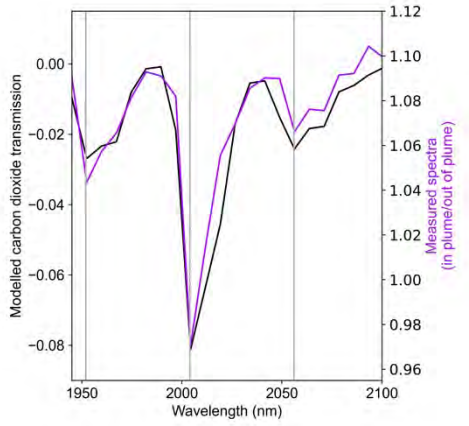
CH_4 spectral fingerprint from EMIT radiance data



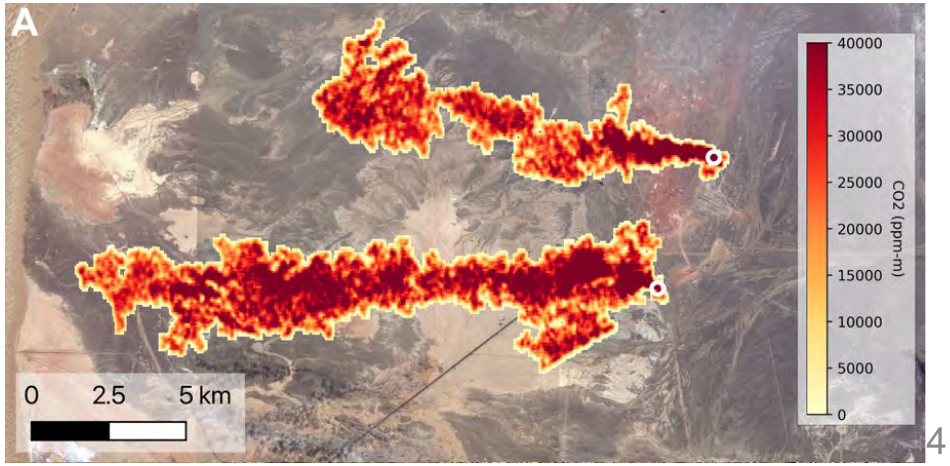
EMIT CH_4 from landfill (Iran)



CO_2 spectral fingerprint



EMIT CO_2 from power plants (China)



NASA imaging spectrometers

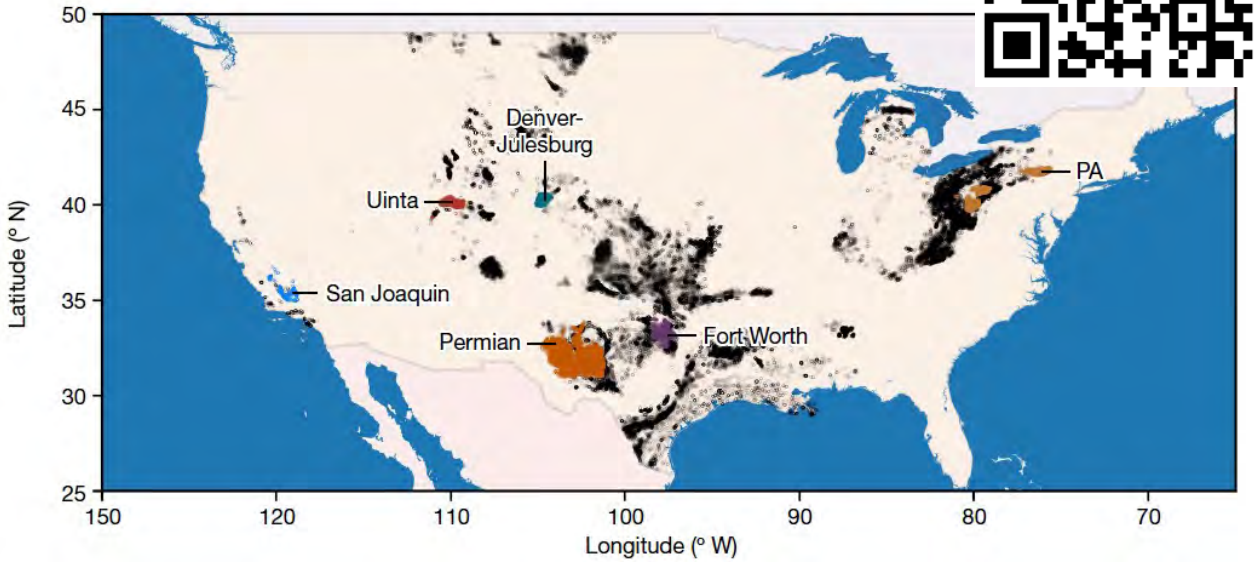
Parameter	EMIT	AVIRIS-3	AVIRIS-5
Platform	ISS	Aircraft	Aircraft
Spectral range	381-2493 nm	381-2493 nm	381-2493 nm
Spectral sampling	7.4 nm	7.4 nm	**5.0 nm (improved gas sensitivity)**
Swath samples	1242	1242	1242
Ground sample distance (GSD)	60 m	Variable (0.25 m at 0.5 km AGL, 10.0 m at 20 km AGL)	Variable (0.25 m at 0.5 km AGL, 10.0 m at 20 km AGL)
Image swath	80 km	Variable (0.36 km at 0.5 km AGL, 14.5 km at 20 km AGL)	Variable (0.36 km at 0.5 km AGL, 14.5 km at 20 km AGL)

Continued need for aircraft studies (AVIRIS-NG, GAO)

nature

US oil and gas system emissions from nearly one million aerial site measurements

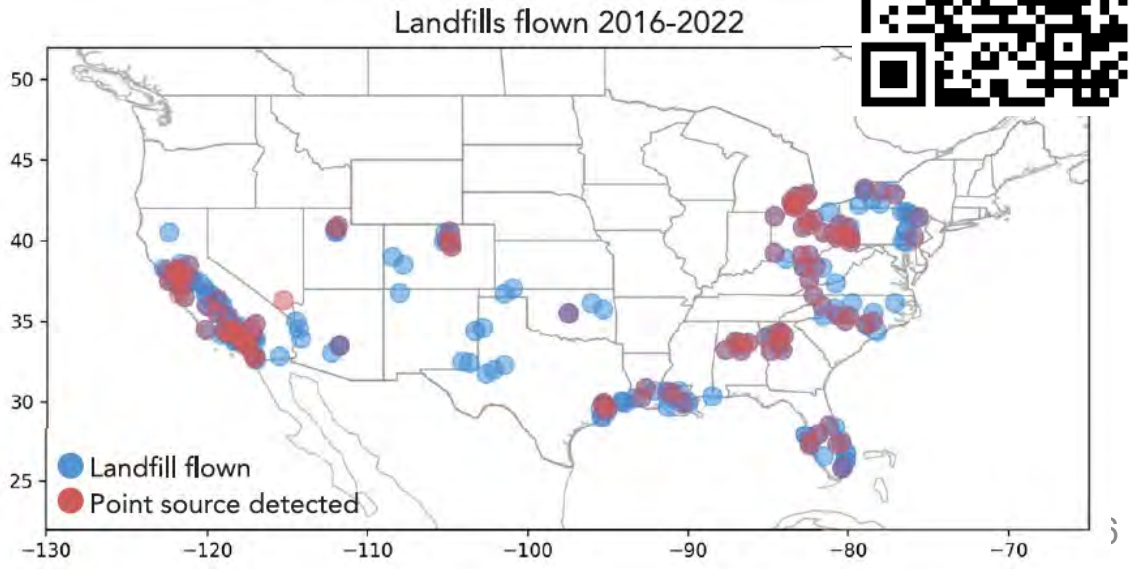
Evan D. Sherwin[1,6]✉, Jeffrey S. Rutherford[1,7], Zhan Zhang[1], Yuanlei Chen[1], Erin B. Wetherley[2], Petr V. Yakovlev[2], Elena S. F. Berman[2], Brian B. Jones[2], Daniel H. Cusworth[3], Andrew K. Thorpe[4], Alana K. Ayasse[3], Riley M. Duren[3,4,5] & Adam R. Brandt[1]



Science

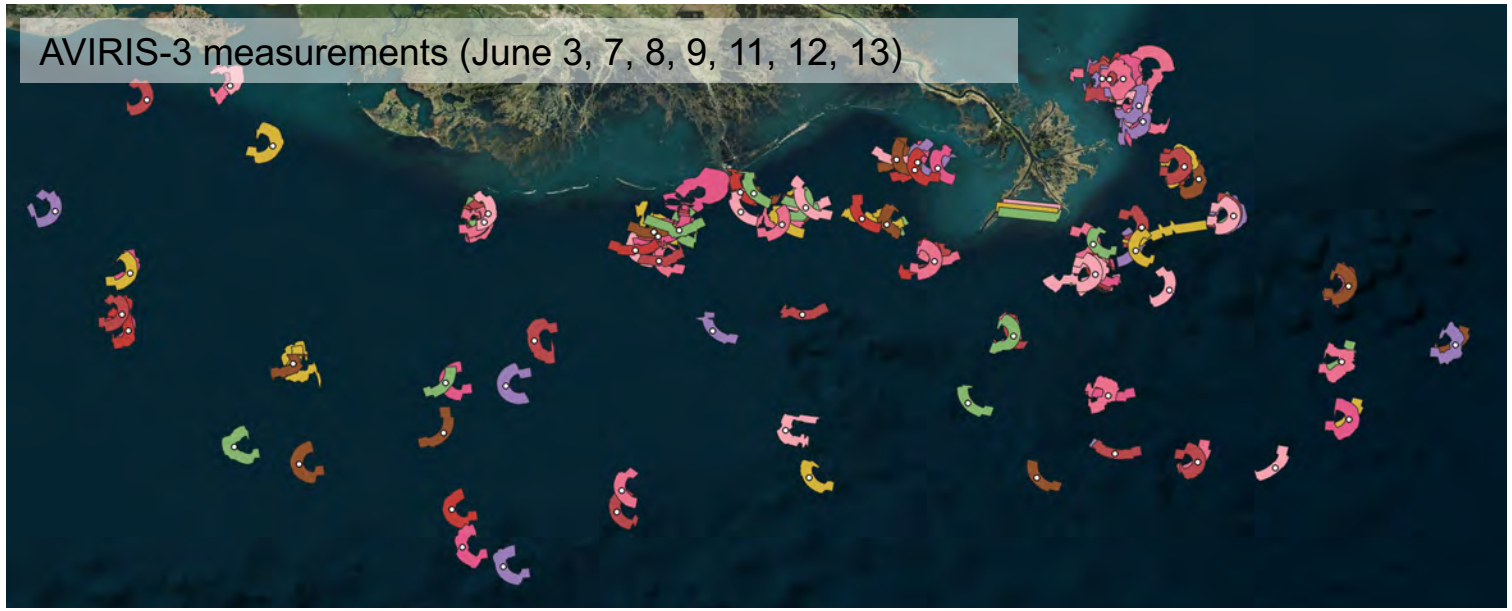
Quantifying methane emissions from United States landfills

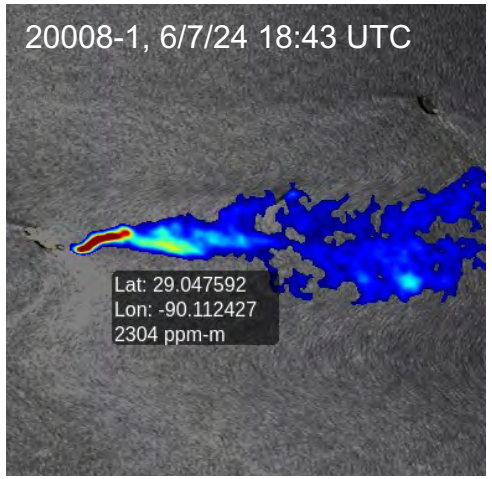
Daniel H. Cusworth[1,2]*, Riley M. Duren[1,2,3], Alana K. Ayasse[1], Ralph Jiorle[1], Katherine Howell[1], Andrew Aubrey[1], Robert O. Green[3], Michael L. Eastwood[3], John W. Chapman[3], Andrew K. Thorpe[3], Joseph Heckler[4], Gregory P. Asner[4], Mackenzie L. Smith[5], Eben Thoma[6], Max J. Krause[6], Daniel Heins[6], Susan Thorneloe[6]

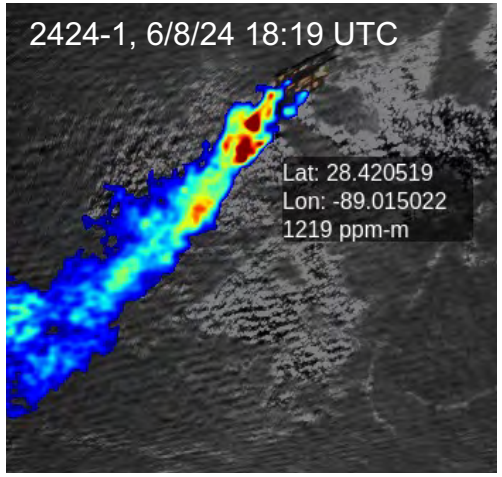


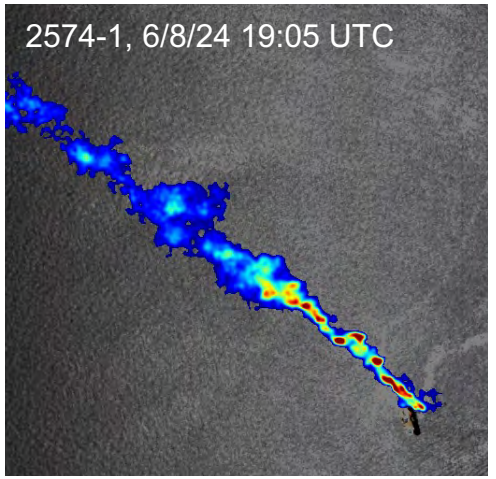
Recent campaigns: NASA SCOAPE-II (June 2024)

- Gulf or Mexico, June 2024
- Lead by Ryan Stauffer (GSFC), support by Bureau of Ocean Energy Management
- AVIRIS-3 sunglint observations for CH_4 from offshore platforms in coordination with ship measurements







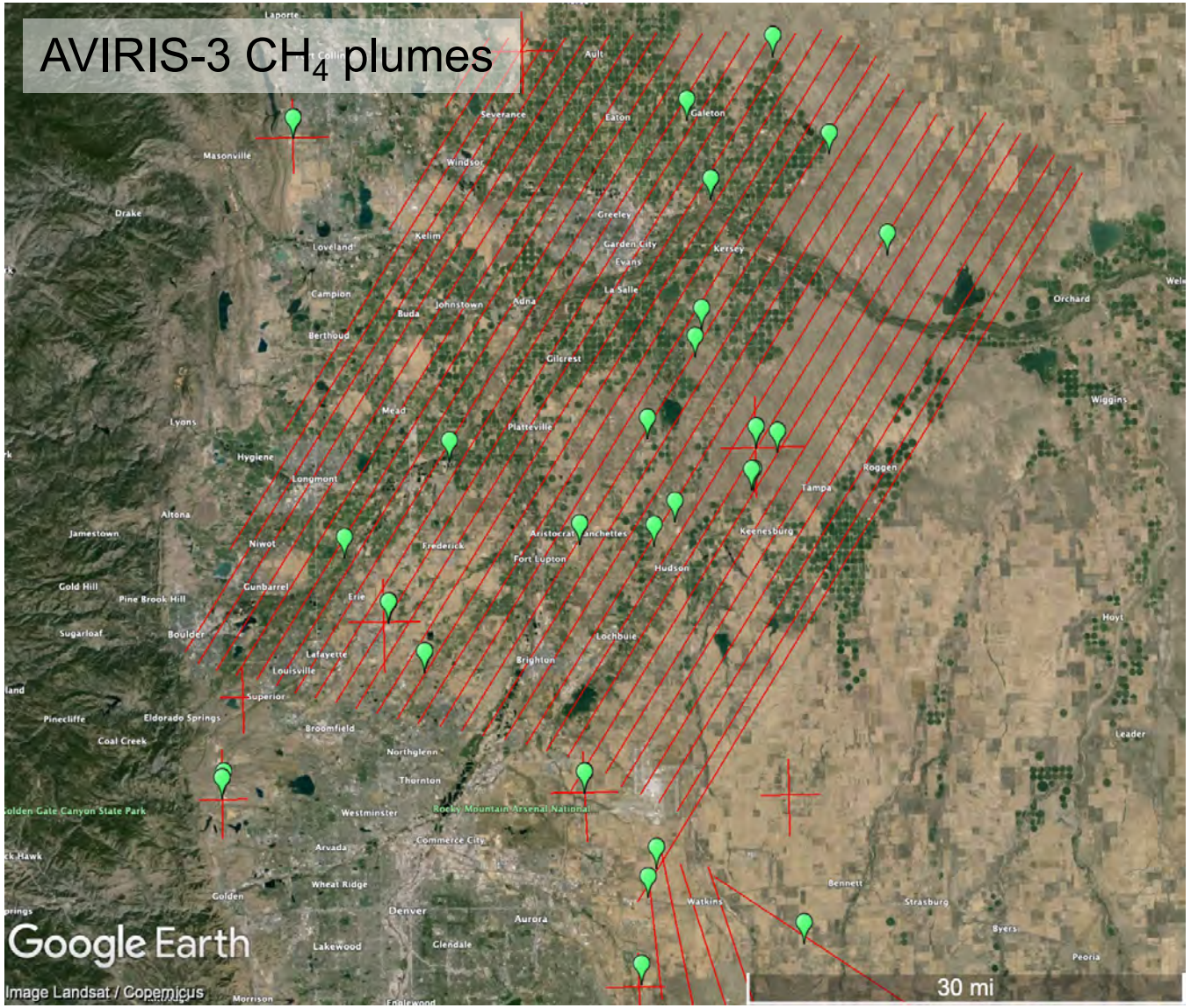


BOEM & NASA SATELLITE COASTAL AND OCEANIC ATMOSPHERIC POLLUTION EXPERIMENT
SCOAPE II

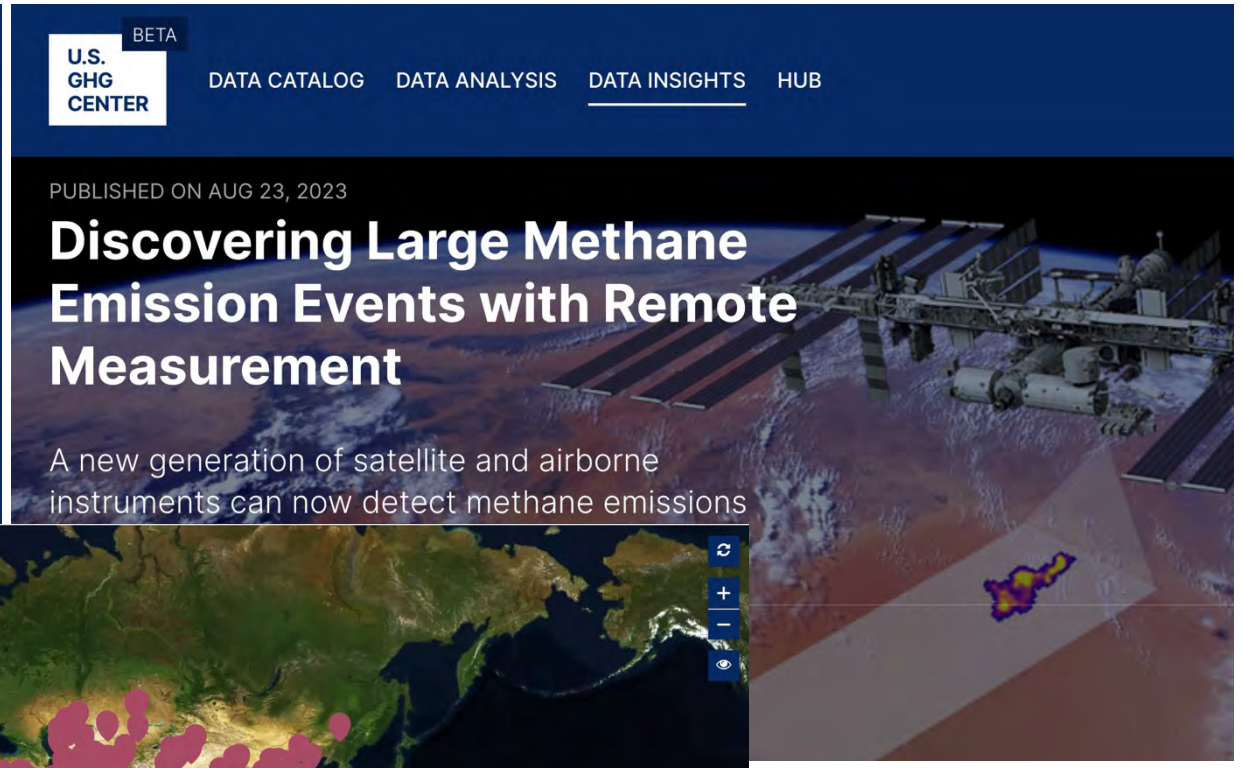
BOEM
Bureau of Ocean Energy Management

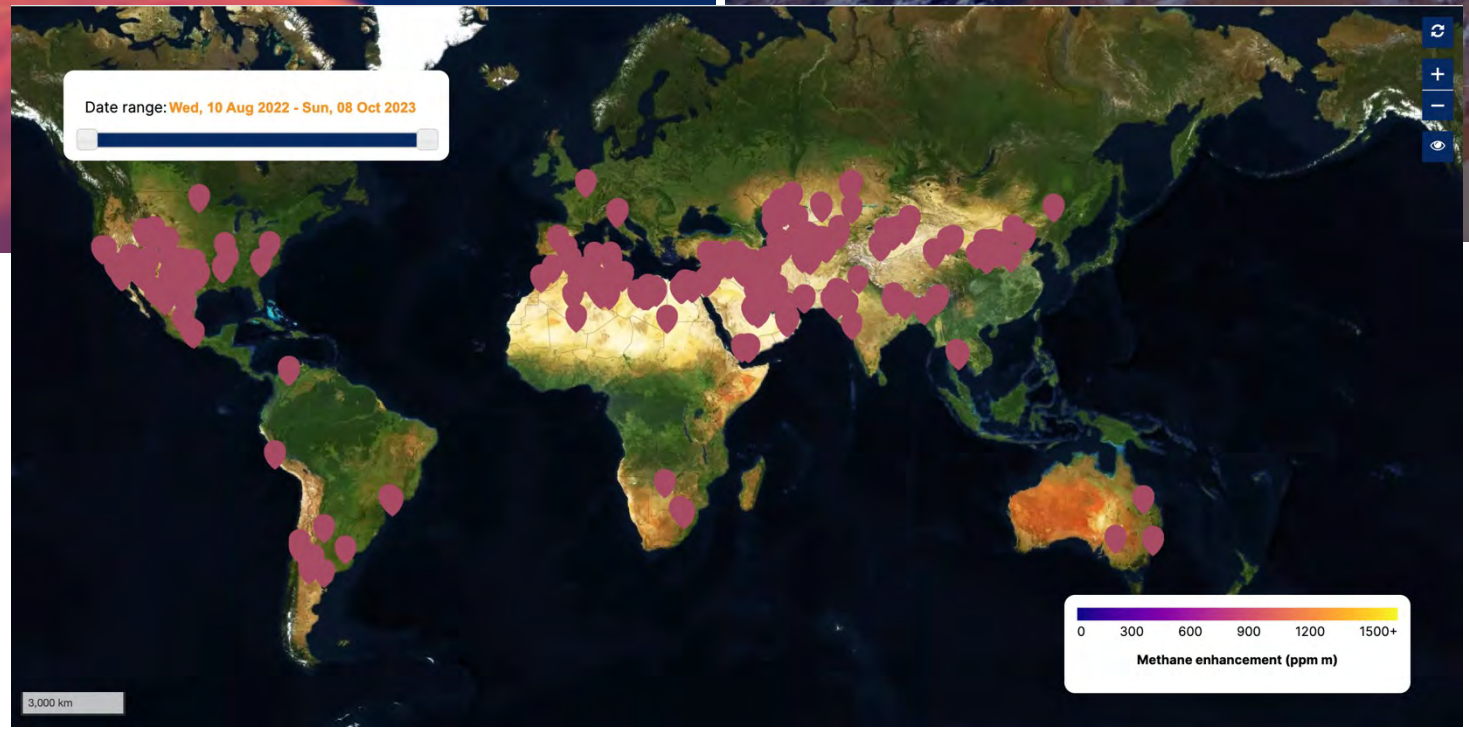
Recent campaigns: NOAA AiRMAPS

- Denver Julesburg Basin, July 2024
- Lead by Steven Brown (NOAA), support by Colorado Department of Public Health and Environment
- AVIRIS-3 flights funded by US GHG Center in coordination with NOAA Twin Otter Mass Balance flights
- >40 CH_4 plumes identified with AVIRIS-3



EMIT CH_4 data available through U.S. GHG Center





Planned:

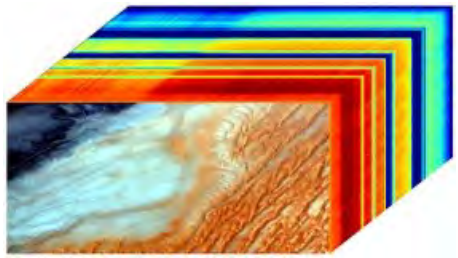
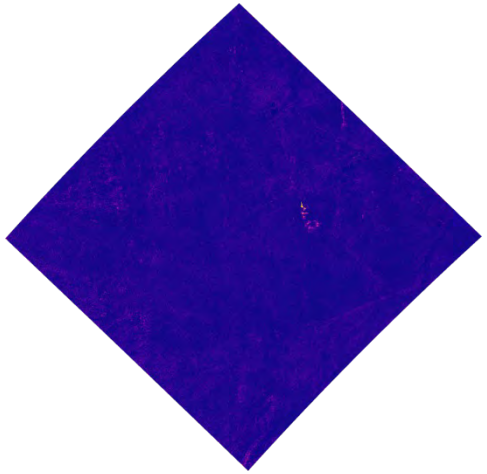
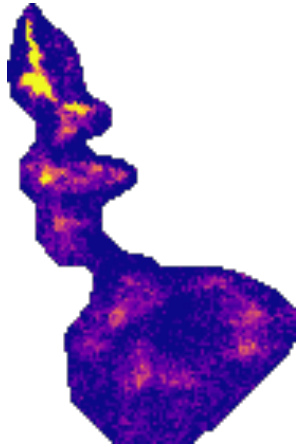
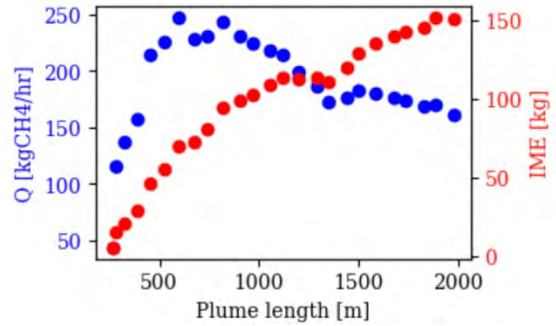
- **EMIT CO_2 results**
- **AVIRIS-3 CH_4 and CO_2 results**

Planned CH_4 and CO_2 airborne campaigns

- CY 2024
  - Controlled CH_4 release: EMIT & AVIRIS-3 coordinated observations [US GHG Center]
  - Coordinated observations: EMIT & AVIRIS-3 [US GHG Center]
  - Controlled CH_4 release: AVIRIS-3 [Carbon Mapper]
  - Urban flights (including Los Angeles): AVIRIS-3 [US GHG Center]
  - Coordinated observations: Tanager 1 instrument (Carbon Mapper Coalition) & AVIRIS-3

- CY 2025 [TBC]
  - Controlled CH_4 release: EMIT & AVIRIS-3/AVIRIS-5 coordinated observations [US GHG Center]
  - Coordinated observations: EMIT & AVIRIS-3/AVIRIS-5 [US GHG Center]
  - NOAA AiRMAPS (Pittsburg, Baltimore): AVIRIS-3/AVIRIS-5 [US GHG Center]
  - Support of NOAA, NIST, EPA, NASA needs: AVIRIS-3 /AVIRIS-5 [US GHG Center]
  - Coordinated observations: Tanager 1 instrument (Carbon Mapper Coalition) & AVIRIS-3/AVIRIS-5

Data products relevant to super-emitters

EMIT Level 1B: Calibrated radiance & geolocation **LP DAAC**  	**Level 2B: Methane enhancement maps** 	**Level 2B: Methane plumes** 	**Level 3: Methane emission rates with uncertainties (planned)** 
	Level 2B: CO2 enhancement maps (planned)	**Level 2B: CO2 plumes (planned)**	**Level 3: CO2 emission rates with uncertainties (planned)**
AVIRIS-3 Level 1B: Calibrated radiance & geolocation (planned) **ORNL DAAC**	**Level 2B: Methane enhancement maps (planned)**	**Level 2B: Methane plumes (planned)**	**Level 3: Methane emission rates with uncertainties (planned)**
	Level 2B: CO2 enhancement maps (planned)	**Level 2B: CO2 plumes (planned)**	**Level 3: CO2 emission rates with uncertainties (planned)**

Open science repositories: [1]https://github.co/emit-sds [2]https://github.com/emit-sds/emit-ghg