Building a scientific basis for tackling anthropogenic methane emissions

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California Air Resource Board

Methane mitigation: challenge & opportunity

Reasons to mitigate CH_4

- Use natural gas fuel more efficiently
- Reduce global warming
- Improve safety and air quality
- Technologically and economically feasible

Anthropogenic methane emissions

Table 1. Inventoried global and urban methane emissions by sector for year 2000, from the work of Marcotullio et al. 2013.

Sector	Global Emissions[a]	percent of total CH_4	Urban Emissions[a]	Urban CH_4 as a percent of total CH_4	percent of urban CH_4
Agriculture	3526	54	186	3	13
Energy	1560	24	645	10	46
Waste	1445	22	561	9	40
Transportation	18	0	9	0	1
Total	6549	100	1401	21	100

[a]Emissions are given as Tg CO_2-equivalent.

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Urban methane emissions

- Large and growing with urbanization and natural gas use
- Concentrated in urban setting
- Municipal control/influence over major sources

Urban methane emissions

Why Cities Are Key to Success at the Paris Climate Talks

Local transit and energy initiatives can scale up to significant carbon savings.

LAURA BLISS | @mslaurabliss | Nov 24, 2015 | 9 Comments

Bliss, L. (2015, November 24). Why Cities Are Key to Fighting Climate Change. Retrieved March 24, 2016, from http://www.citylab.com/cityfixer/2014/04/why-cities-are-key-fighting-climate-change/8863/

World mayors sign climate-change pact in Mexico City

NOVEMBER 22, 2010 | 8:23 AM

Hernandez, D. (2010, November 22). World mayors sign climate-change pact in Mexico City. Retrieved March 24, 2016, from http://latimesblogs.latimes.com/laplaza/2010/11/mayors-climate-change-mexico-city.html

California joins other states, provinces in climate change agreement

California Gov. Jerry Brown is surrounded by Chinese delegates after a discussion on energy innovation and reducing carbon emissions in Beijing in 2013. (Andy Wong / Associated Press)

Megerian, C. (2015, May 19). California joins other states, provinces in climate change agreement. Retrieved March 24, 2016, from http://www.latimes.com/local/political/la-me-pc-jerry-brown-california-international-climate-change-20150519-story.html

Methane mitigation: challenge & opportunity

Barriers to mitigating CH_4

We lack basic knowledge of CH_4 emission sources

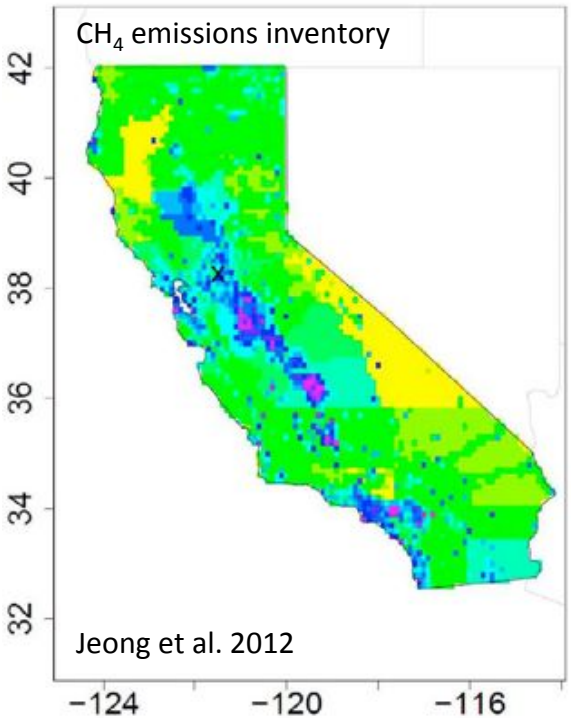
- Locations
- Relative strengths
- Most effective mitigation solution
- Cost of mitigation
- Who is responsible

AB 32: Global Warming Solutions Act of 2006

California required by law to reduce statewide greenhouse gas emissions by 25% from 2006 levels

Inventory: CH_4 emissions concentrated in the Central Valley and greater Los Angeles

South Coast Air Basin (Greater Los Angeles):
43% of population
35% of CO_2
~30% of CH_4



Framework for methane emissions

Detection: on road surveys to find the leaks

Attribution: use spatial patterns and tracer species to determine sources and their contributions to total emissions

Quantification: calculate CH_4 flux using seasonally averaged data and relationships between urban trace gas emissions

Mitigation: how effective are current mitigation approaches

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Detecting methane emissions at the city scale: mobile laboratory observations

Ford Transit van with modified electrical system and sampling snorkel

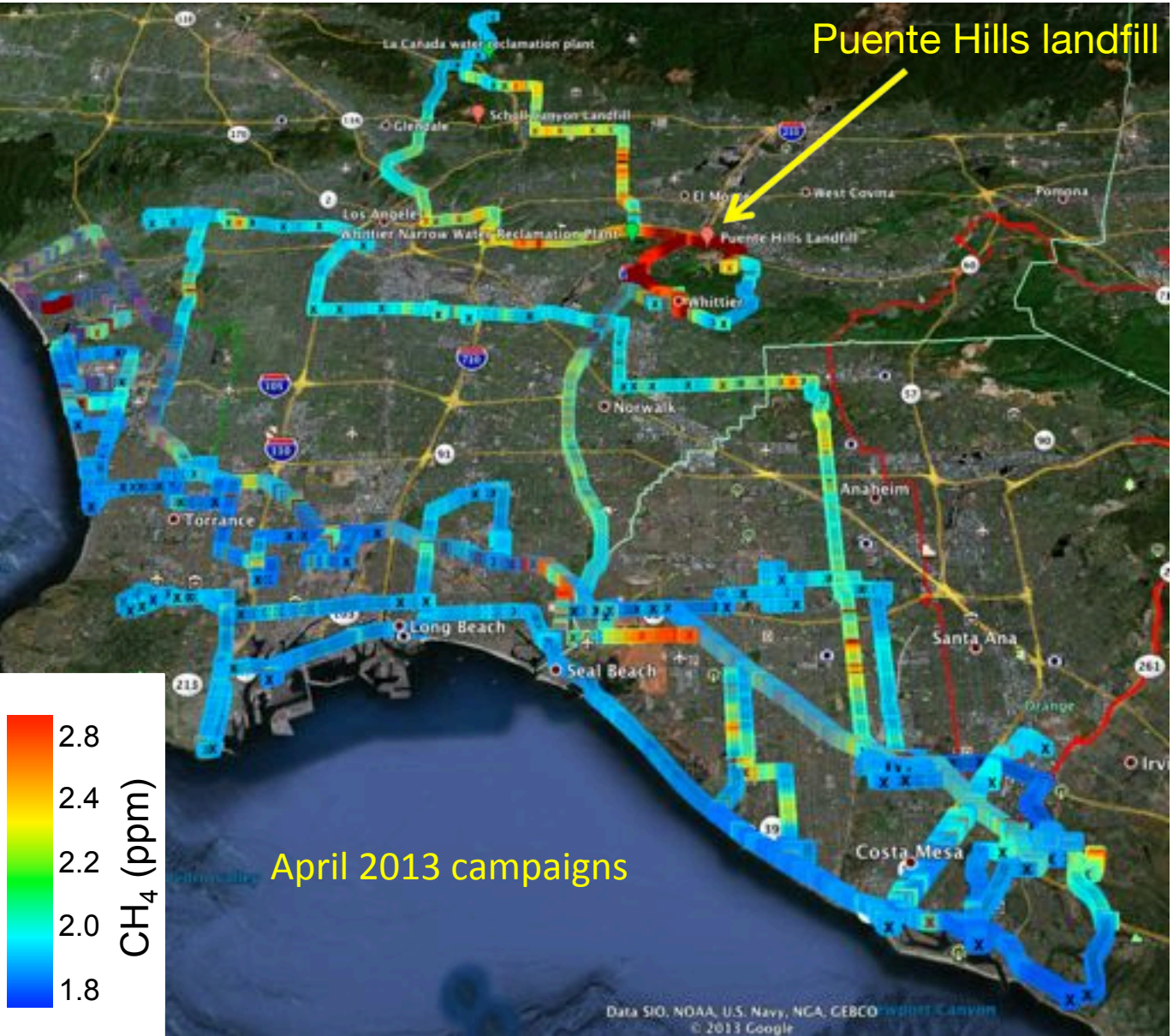
Collaboration between UC Irvine, University of Utah, San Diego State

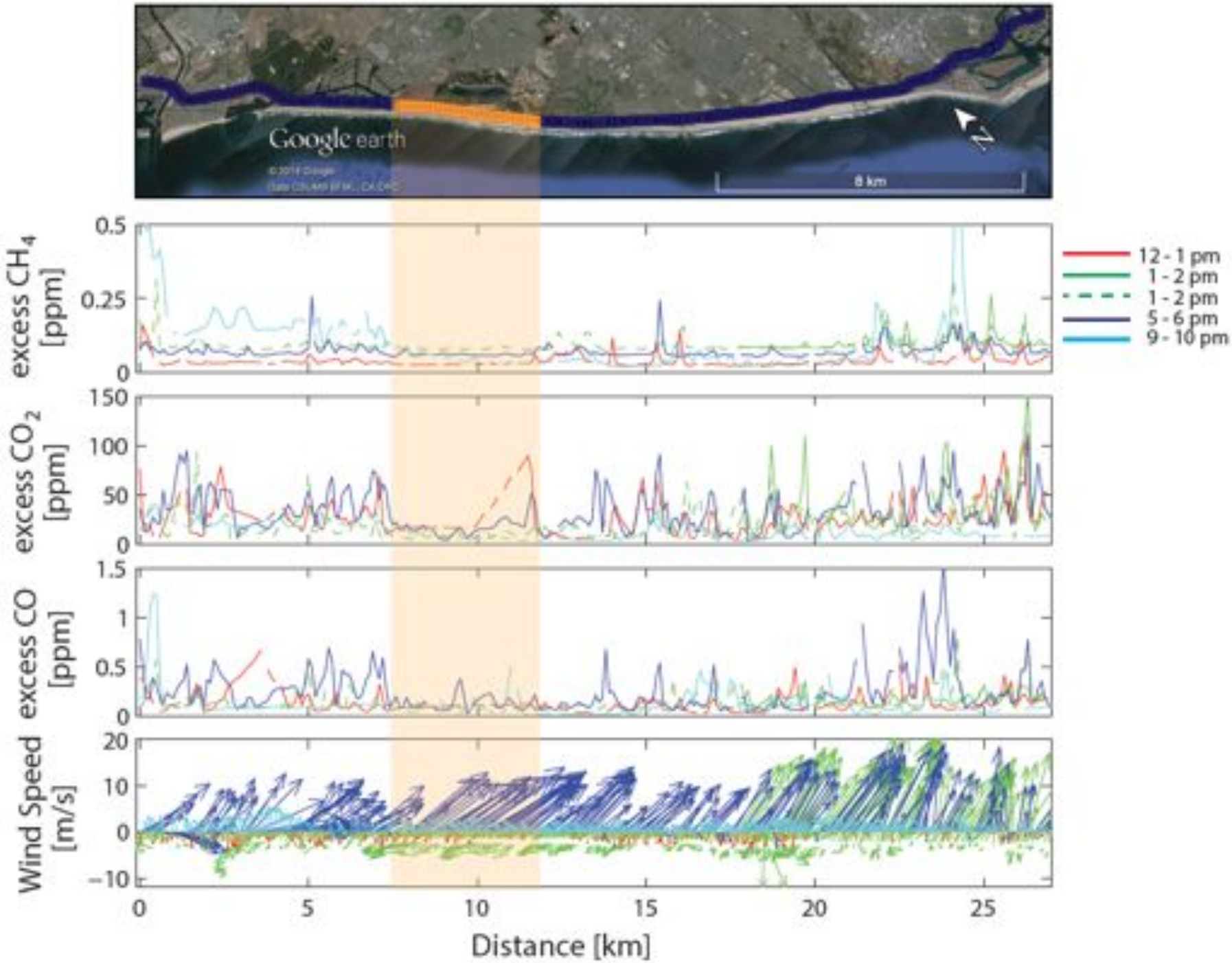
Deployed in Los Angeles, Salt Lake City, and San Diego

High-frequency trace gas measurements using newly available, state-of-the-art instruments

Measurements of greenhouse gases and criteria pollutants: CO_2, CH_4, CO, C_2H_6, O_3

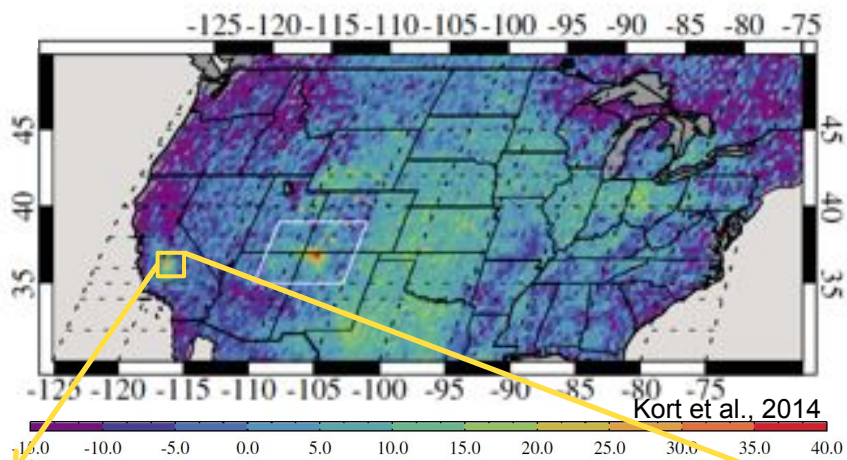
Detect spatial patterns in methane




Google earth
8 km
N
excess CH_4 [ppm]
0.5
0.25
0
excess CO_2 [ppm]
150
100
50
0
excess CO [ppm]
1.5
1
0.5
0
Wind Speed [m/s]
20
10
0
−10
0
5
10
15
20
25
Distance [km]
12 - 1 pm
1 - 2 pm
1 - 2 pm
5 - 6 pm
9 - 10 pm

Satellite CH_4 detection and airborne follow up

SCIAMACHY 2003-2009 avg. CH_4 anomaly (ppb)



Kort et al., 2014

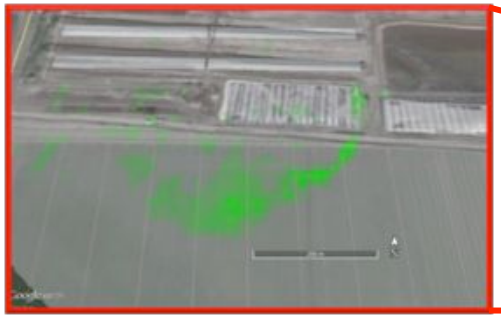
A methane hotspot in the Central Valley has been observed from space (Kort et al. 2014)

Large areas of oil extraction and dairies are large methane sources

Airborne CH_4 imaging

HyTES: airborne imaging spectrometer
256 spectral channels between 7.5 and 12 μm
512 pixels cross track

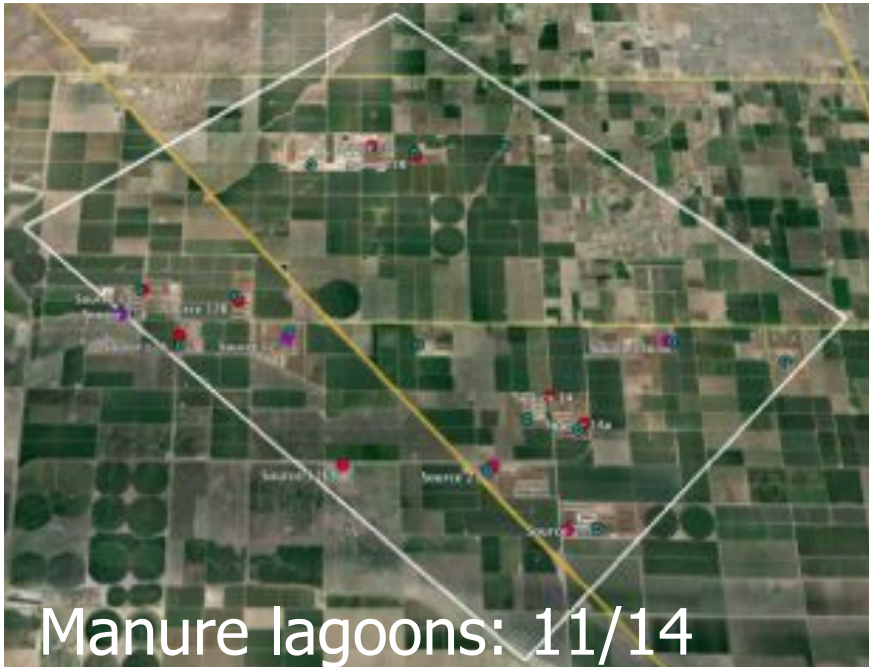
Repeated surveys to image CH_4 plumes

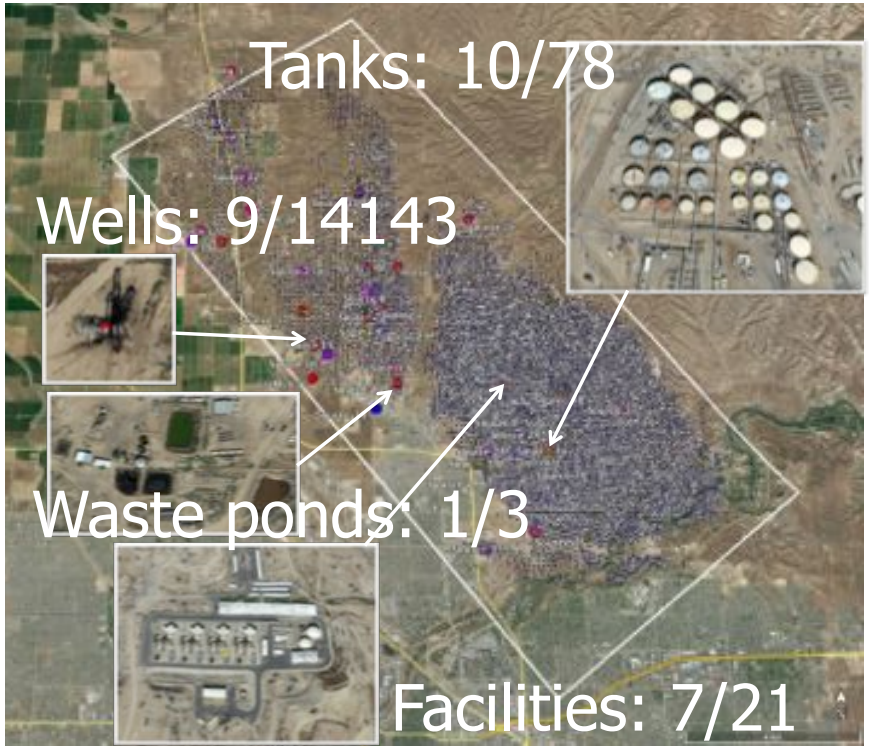


CH_4 observations in California's Central Valley

Dairies:

- CH_4 sources are all associated with wet manure management
- Most lagoons are leaky





Oil field:

- several different CH_4 sources
- different sectors have different leak rates

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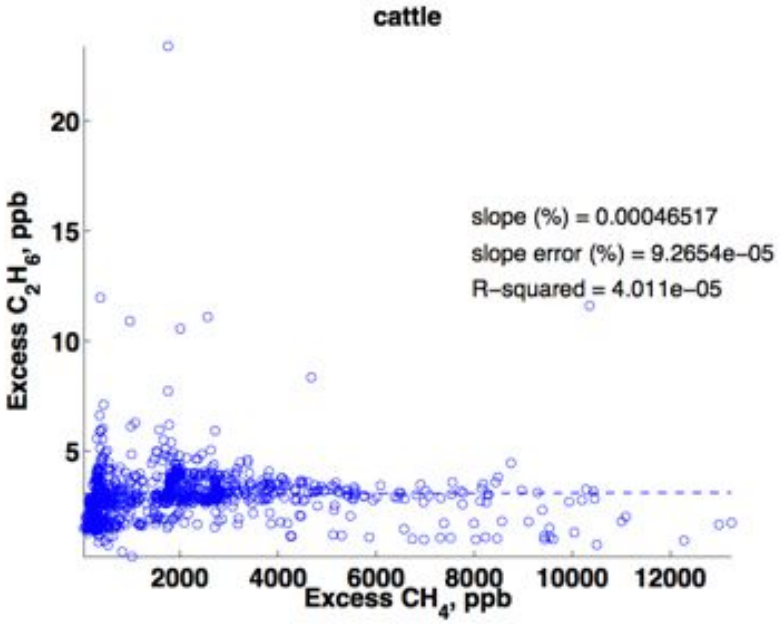
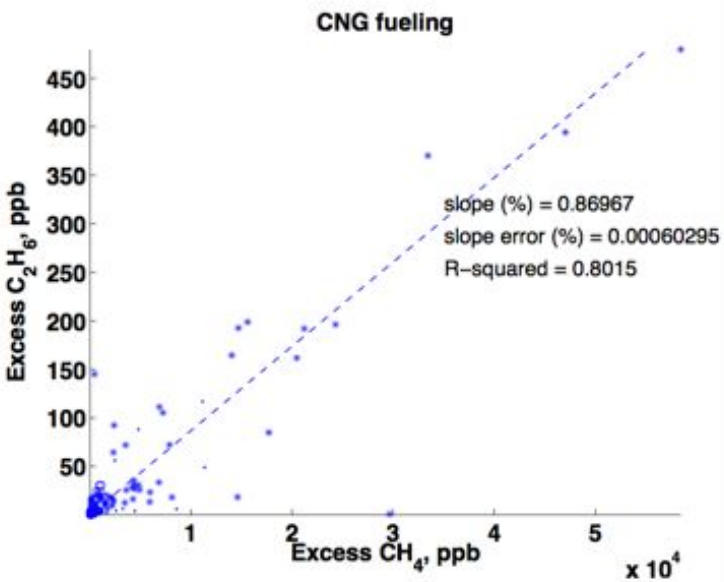
Quantification: calculate CH_4 flux using seasonally averaged data and relationships between urban trace gas emissions

Mitigation: how effective are current mitigation approaches

Mobile laboratory: directly measure emissions ratios of C_2H_6 to CH_4 for known CH_4 sources

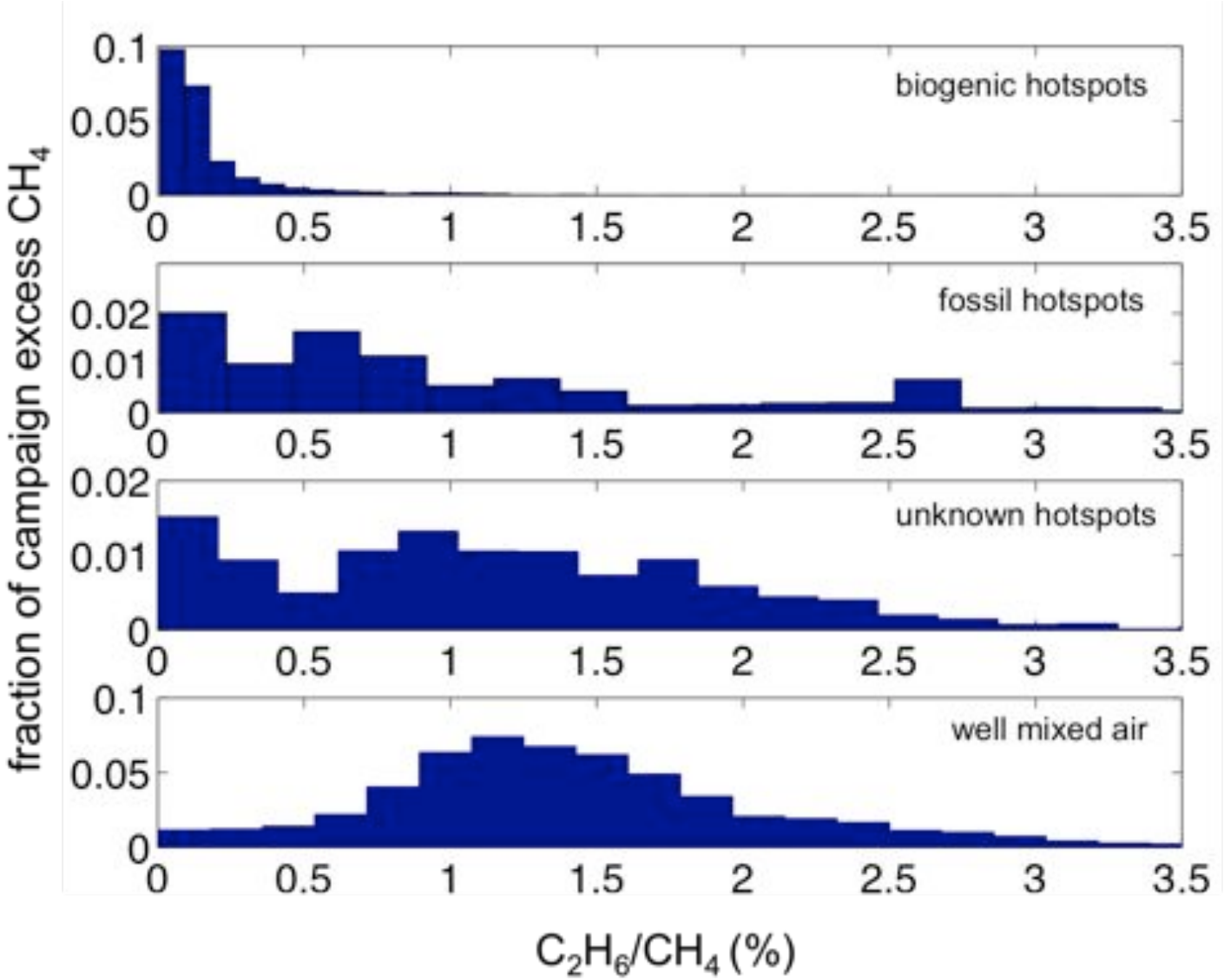
Biogenic CH_4



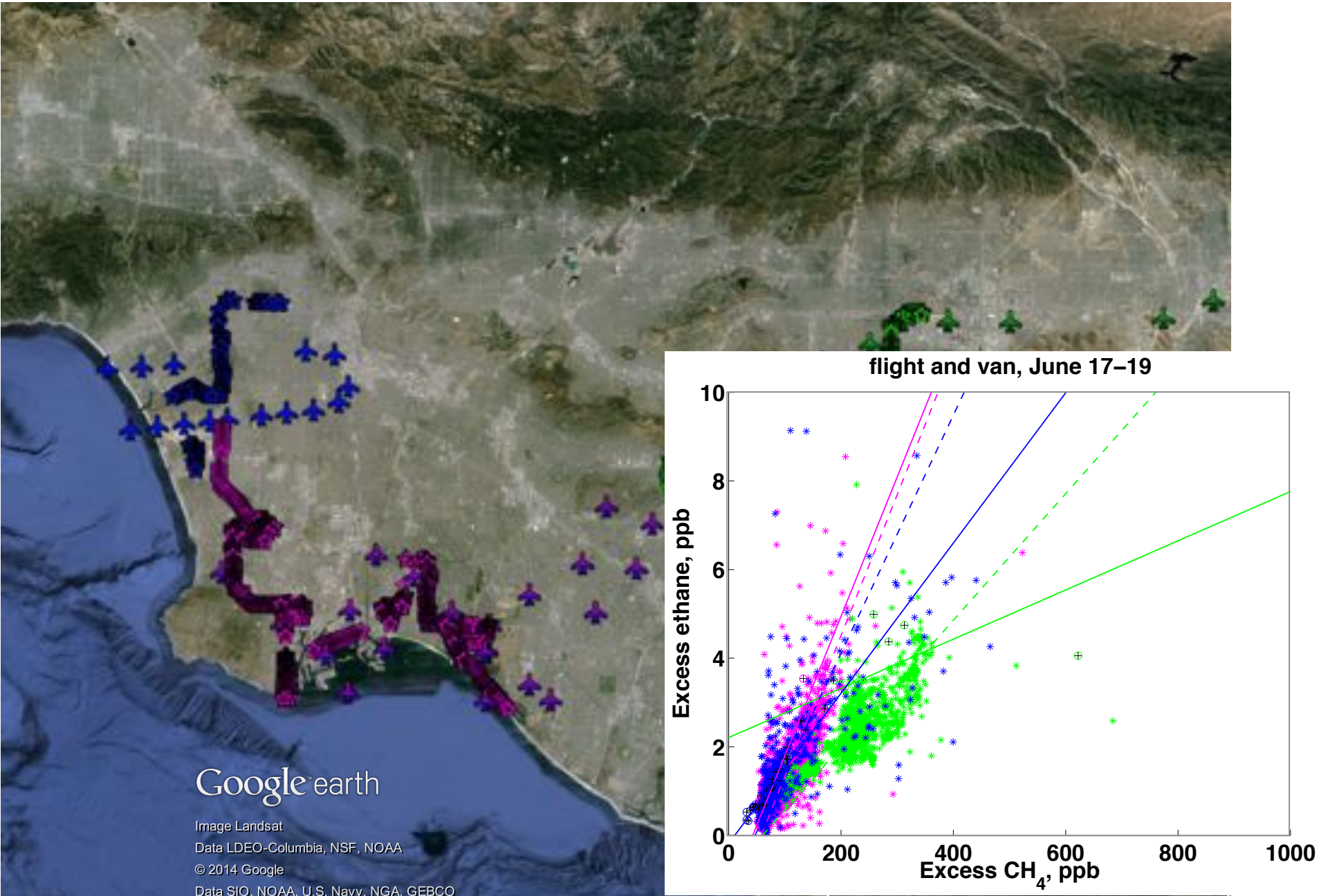


Fossil CH_4

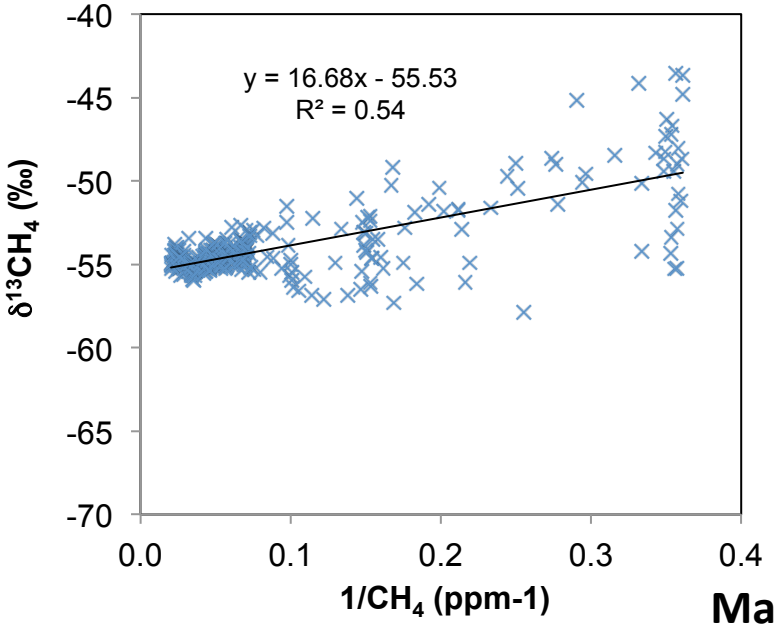
Source apportionment

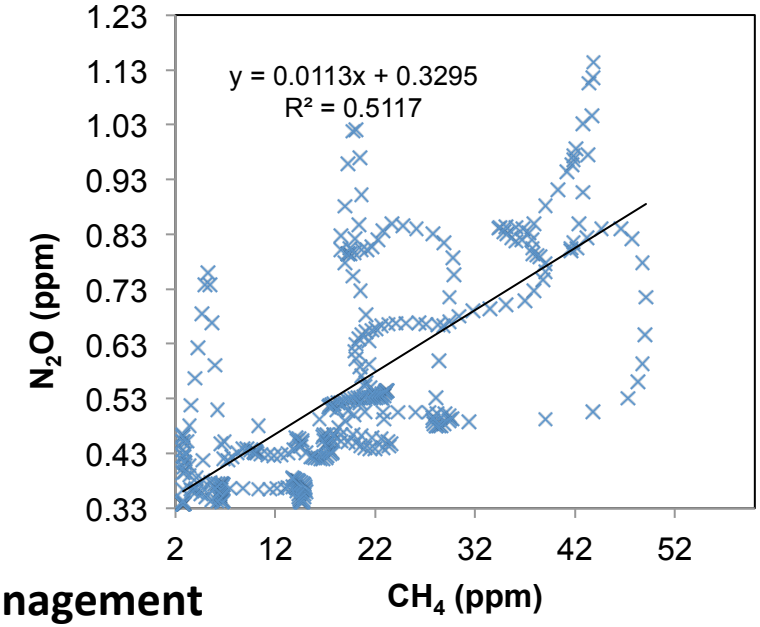


Ethane to methane on road is similar to aircraft

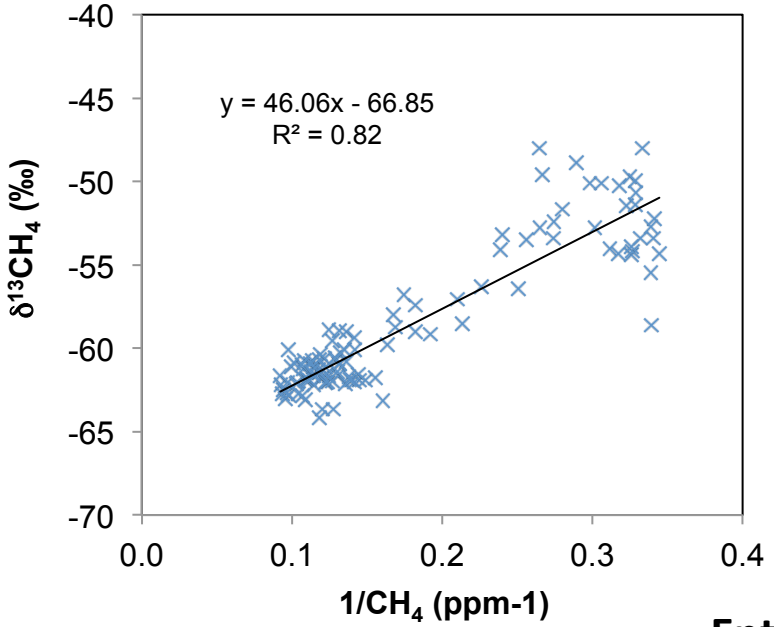


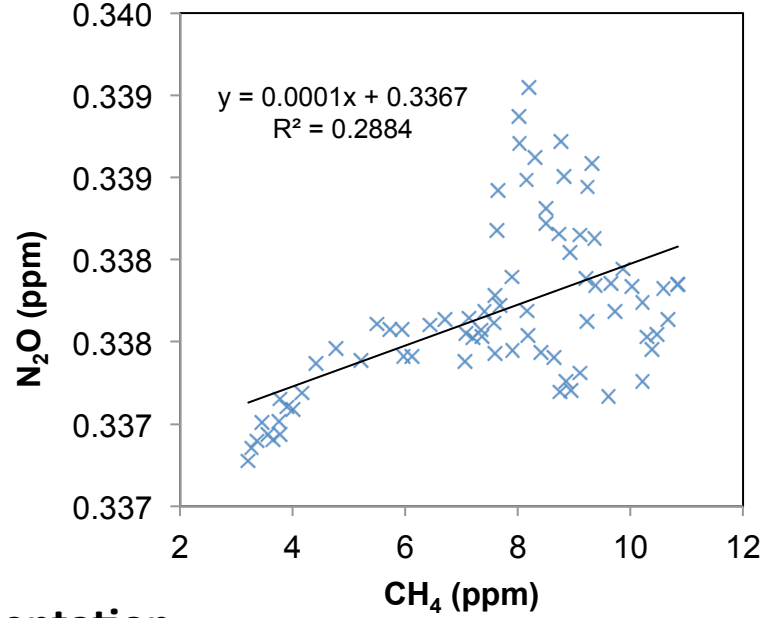
San Joaquin Valley mobile measurements of methane tracers





Manure management





Enteric fermentation

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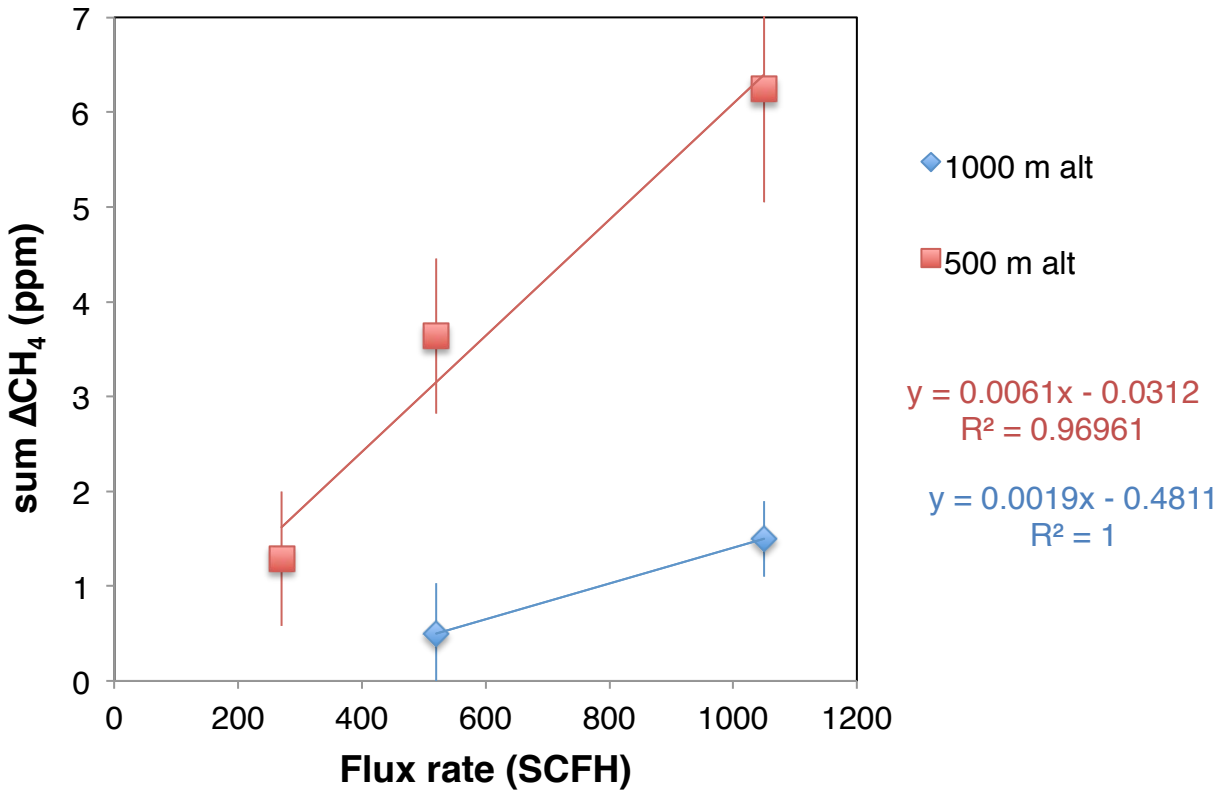
HyTES controlled release experiment

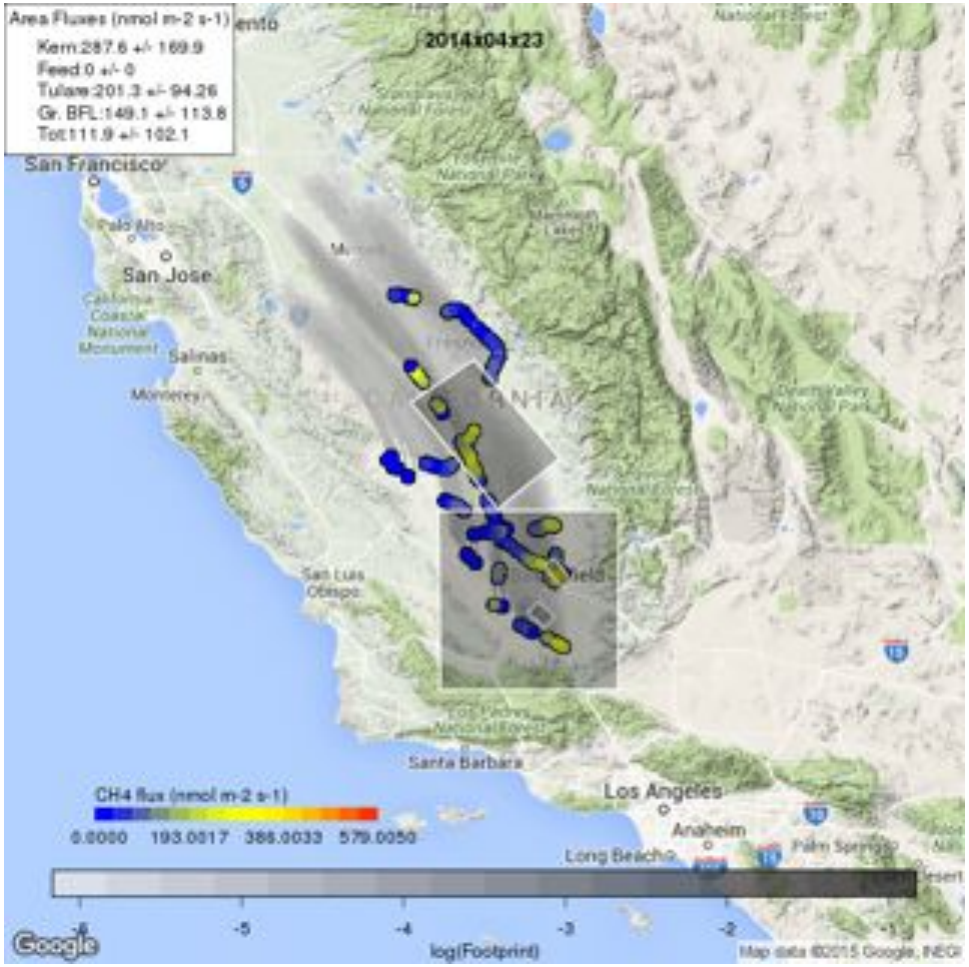
Can HyTES detections be used to estimate fluxes?

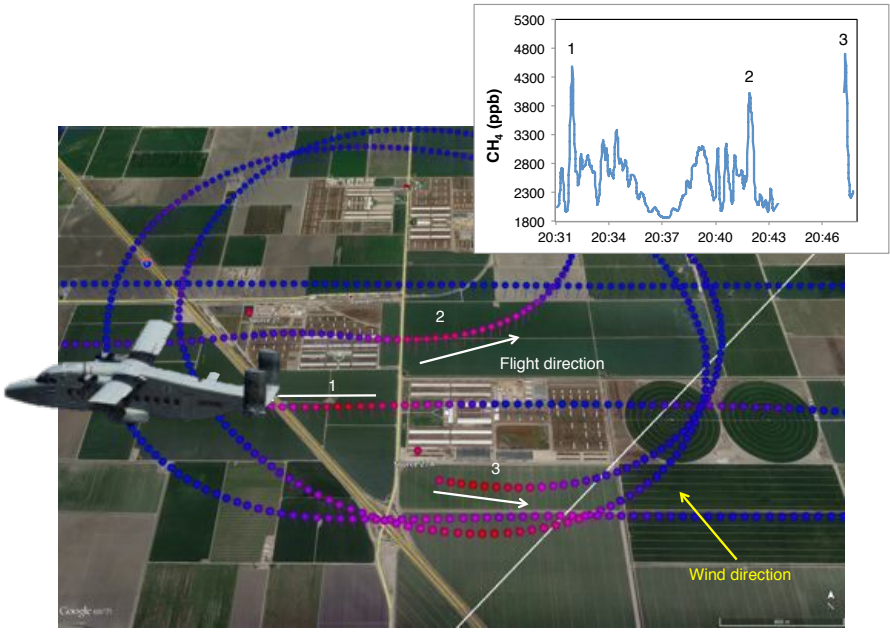
Photos courtesy of Andrew Aubrey, Matthias Falk, Scott Nolte

HyTES controlled release experiment



STILT derived estimates from CARVE aircraft





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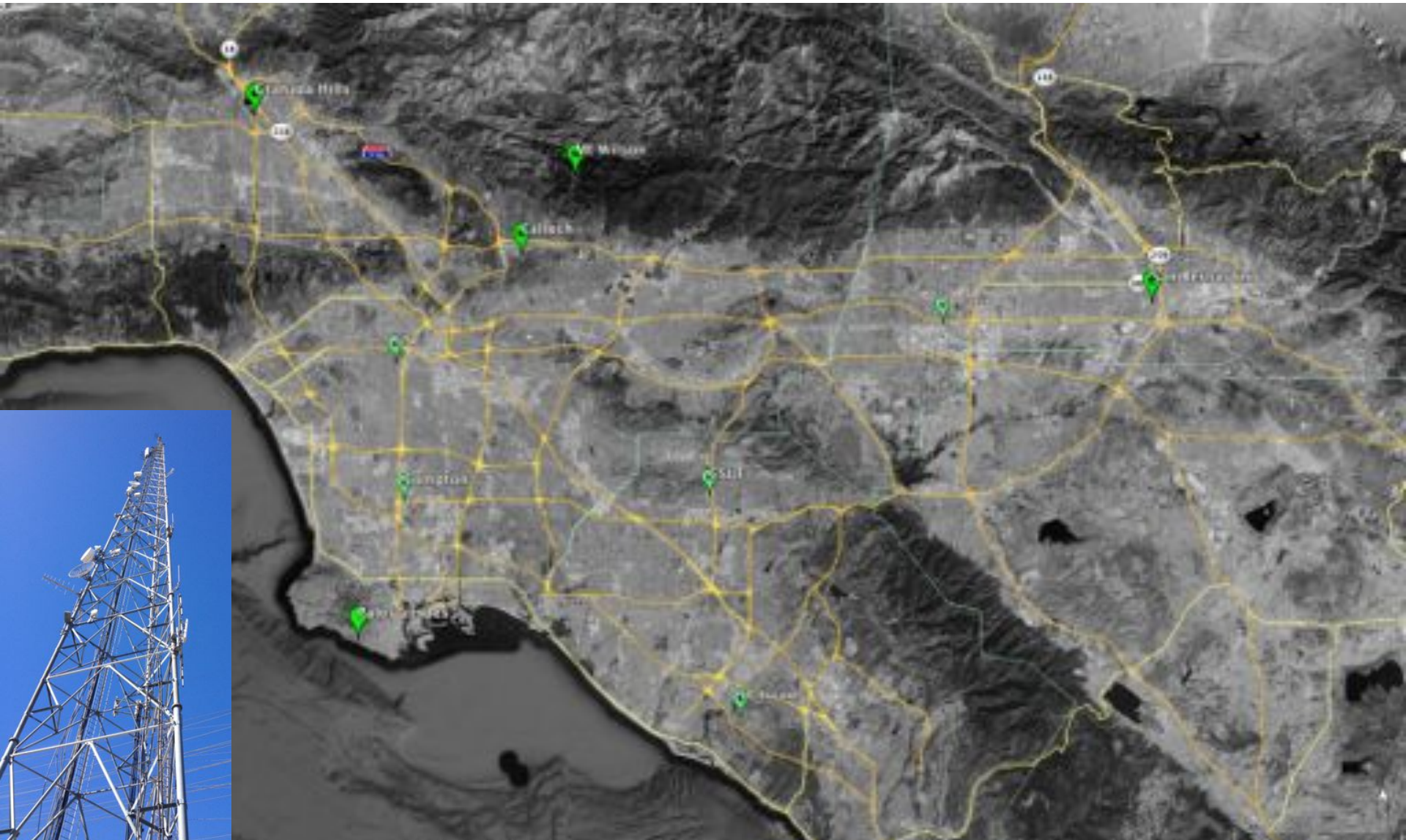
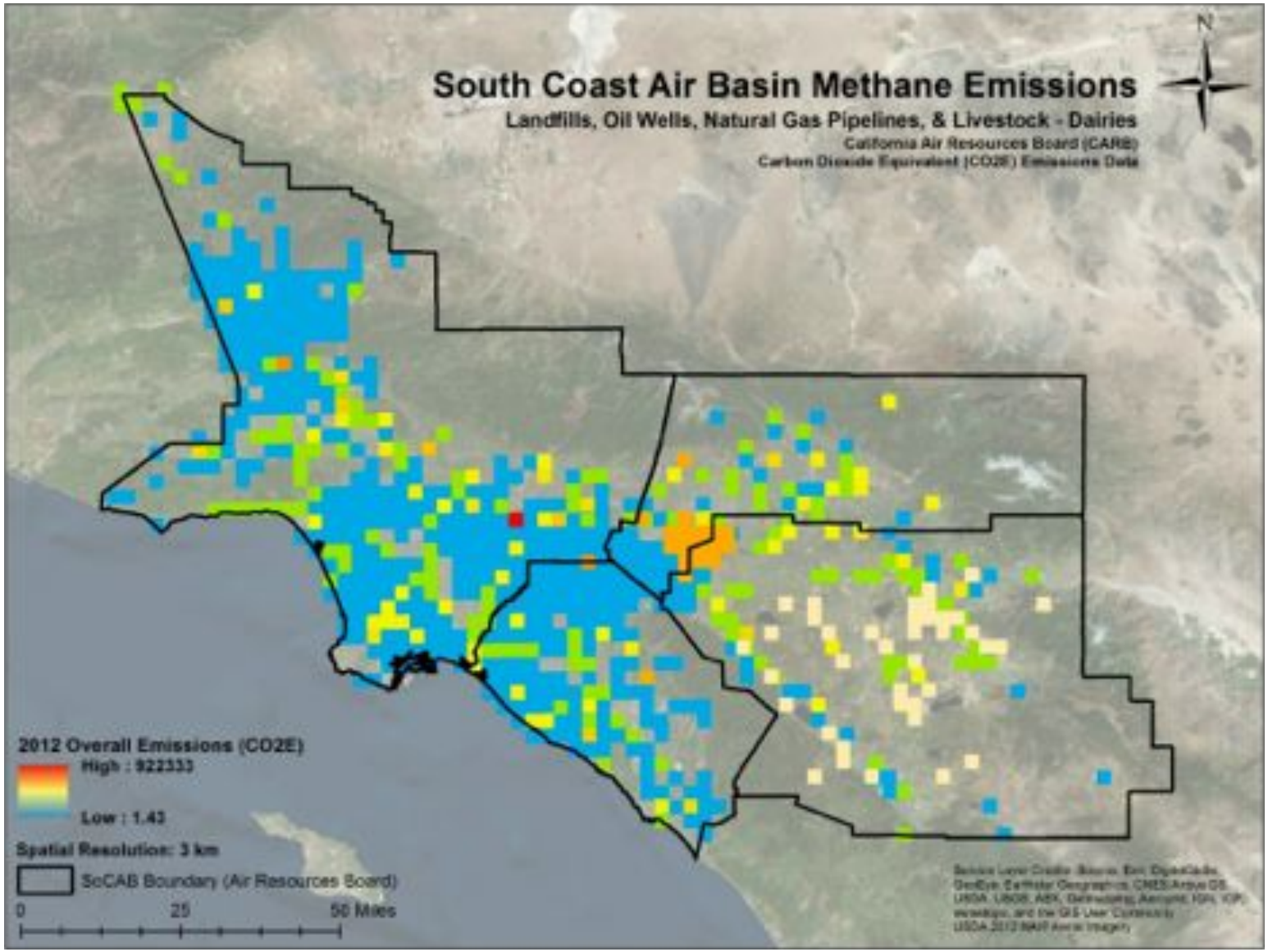
Trend detection:
LA Megacities Tower Network



Fine-scale methane inventory



Mobile survey lessons for L.A. CH_4 mitigation

- Not many large natural gas leaks in LA compared to other cities
- CNG fueling stations are leaky
- Former landfills have inconsistent mitigation that may not reduce CH_4 emissions

Natural gas pipeline leaks detected on road: About 100x rarer in LA than in DC or Boston

Sources of methane: CNG filling stations

Clean Energy-Santa Ana CNG station

Plot by Valerie Carranza

Not included by most inventories

Closed landfills emit CH_4, mitigation is inconsistent

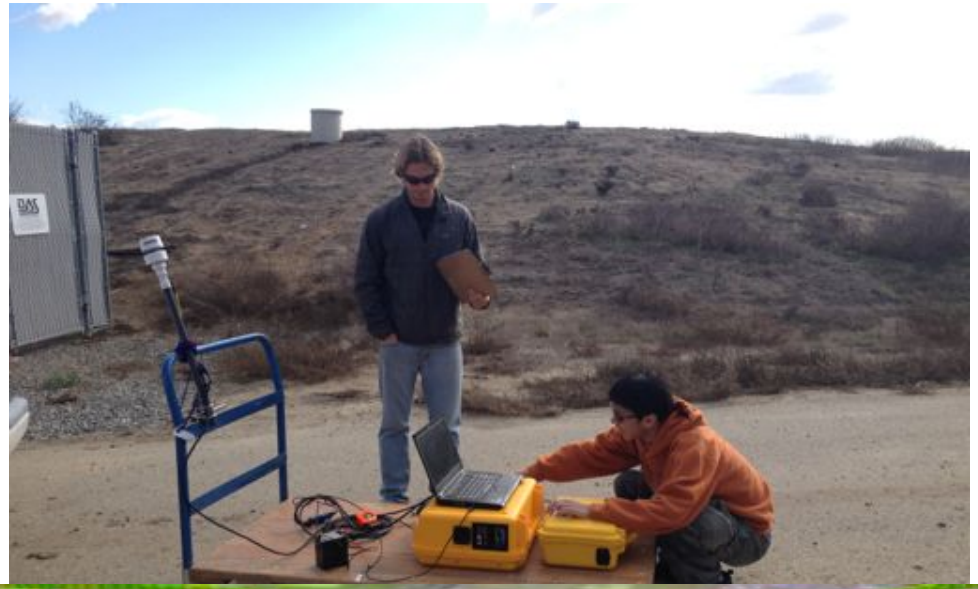
Some former landfills are leaking CH_4, others are not

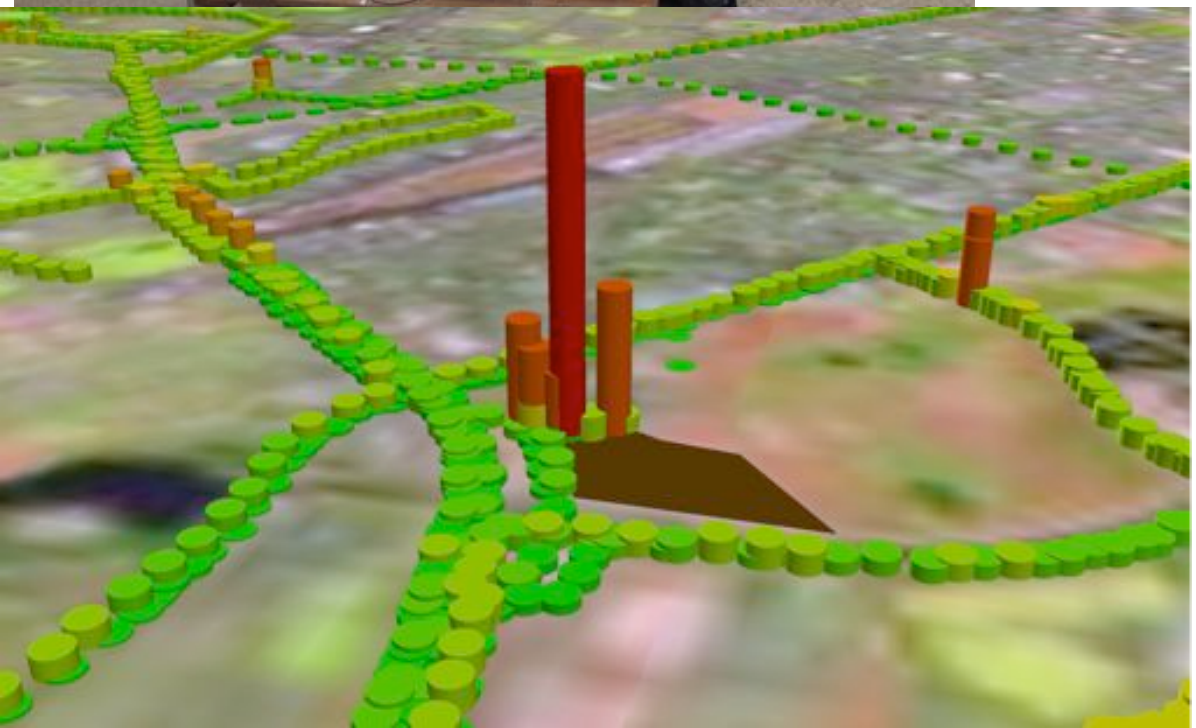
These two landfills are < 8 miles apart, but are located in different cities

Local CH_4 mixing ratio enhancement above background levels

- 0-100 ppb
- 100-200 ppb
- 200-300 ppb
- >300 ppb CH_4

Old landfill on UC Irvine campus: persistent CH_4 hotspot





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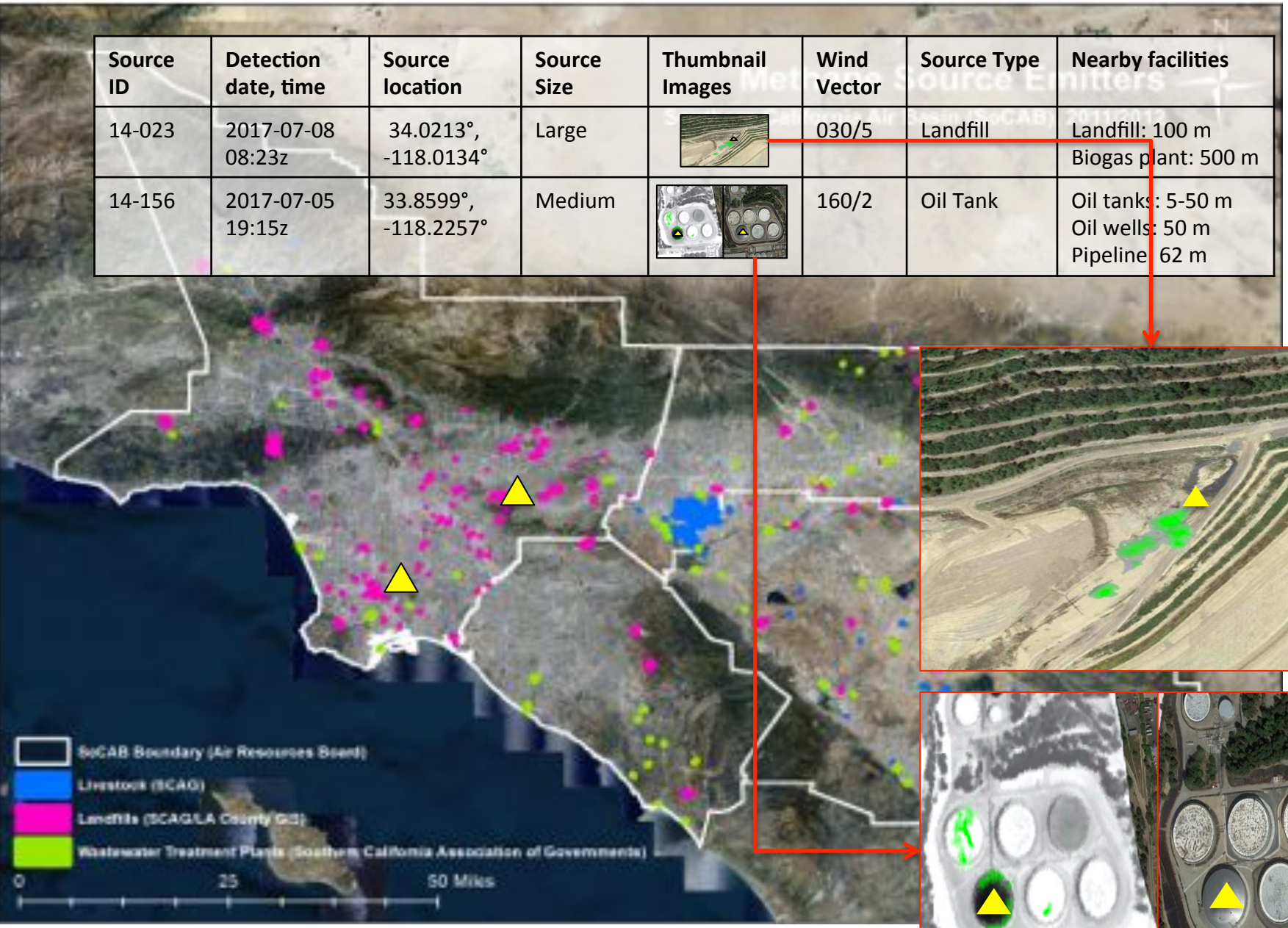
Landfill mitigation practices may not be minimizing CH_4 emissions

- LWIR imaging

Key future hypotheses

- *Urban methane emissions are poised to grow because of ineffective current mitigation practices and increasing use of natural gas and biogas fuels*
  - More studies of the distribution, frequency and rate of fugitive methane across different engineered urban systems
  - Better understanding of how different management practices can affect emissions rates
- *Mitigating urban methane emissions will require new measurements over a range of scales using multiple techniques*
  - Facility-level measurements, attribution studies, and new inventory approaches are needed to resolve discrepancies between purely top-down measurements and traditional activity-based inventories
- *Cities differ greatly in their methane emissions, and require unique mitigation approaches*
  - Interdisciplinary research is needed to understand how differences in economy, population, climate, geography and development affect methane emissions
  - How differences in governance structures, culture, economy, and emitting sectors affect methane mitigation activities and their effectiveness
  - This work will help determine mitigation priorities and best practices among regions

Future work: California HyTES-AVIRIS NG campaign, summer 2016

Source ID	Detection date, time	Source location	Source Size	Thumbnail Images	Wind Vector	Source Type	Nearby facilities
14-023	2017-07-08 08:23z	34.0213°, -118.0134°	Large		030/5	Landfill	Landfill: 100 m Biogas plant: 500 m
14-156	2017-07-05 19:15z	33.8599°, -118.2257°	Medium		160/2	Oil Tank	Oil tanks: 5-50 m Oil wells: 50 m Pipeline: 62 m