Measurement-based approaches to quantify oil and gas methane emissions

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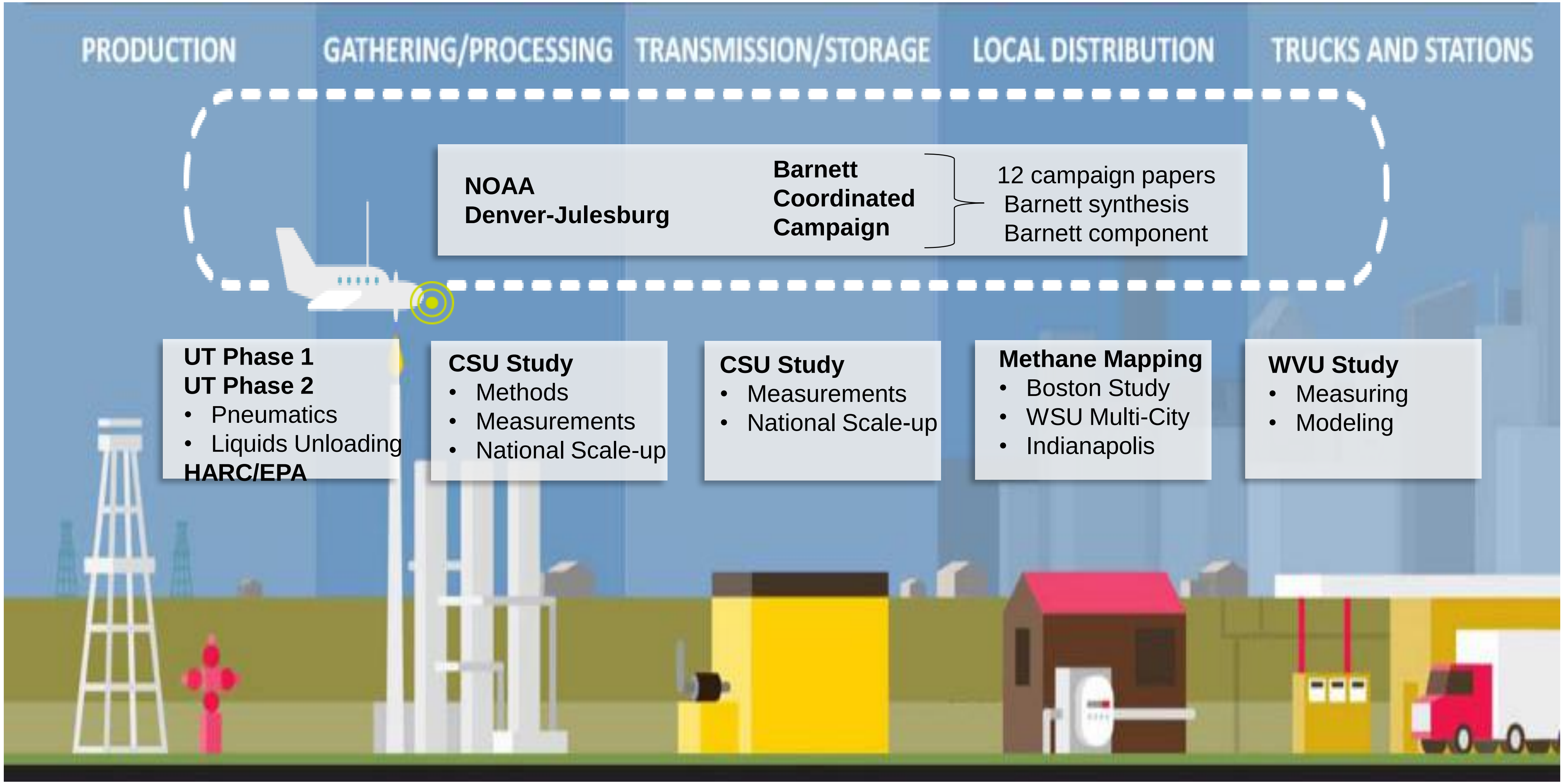
EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

Outline

- Introduction
- EDF oil and gas methane studies
- Top-down vs. bottom-up approaches
- Best estimate of U.S. O&G methane emissions
- PermianMAP project
- Local distribution studies

EDF U.S. O&G CH_4 Studies



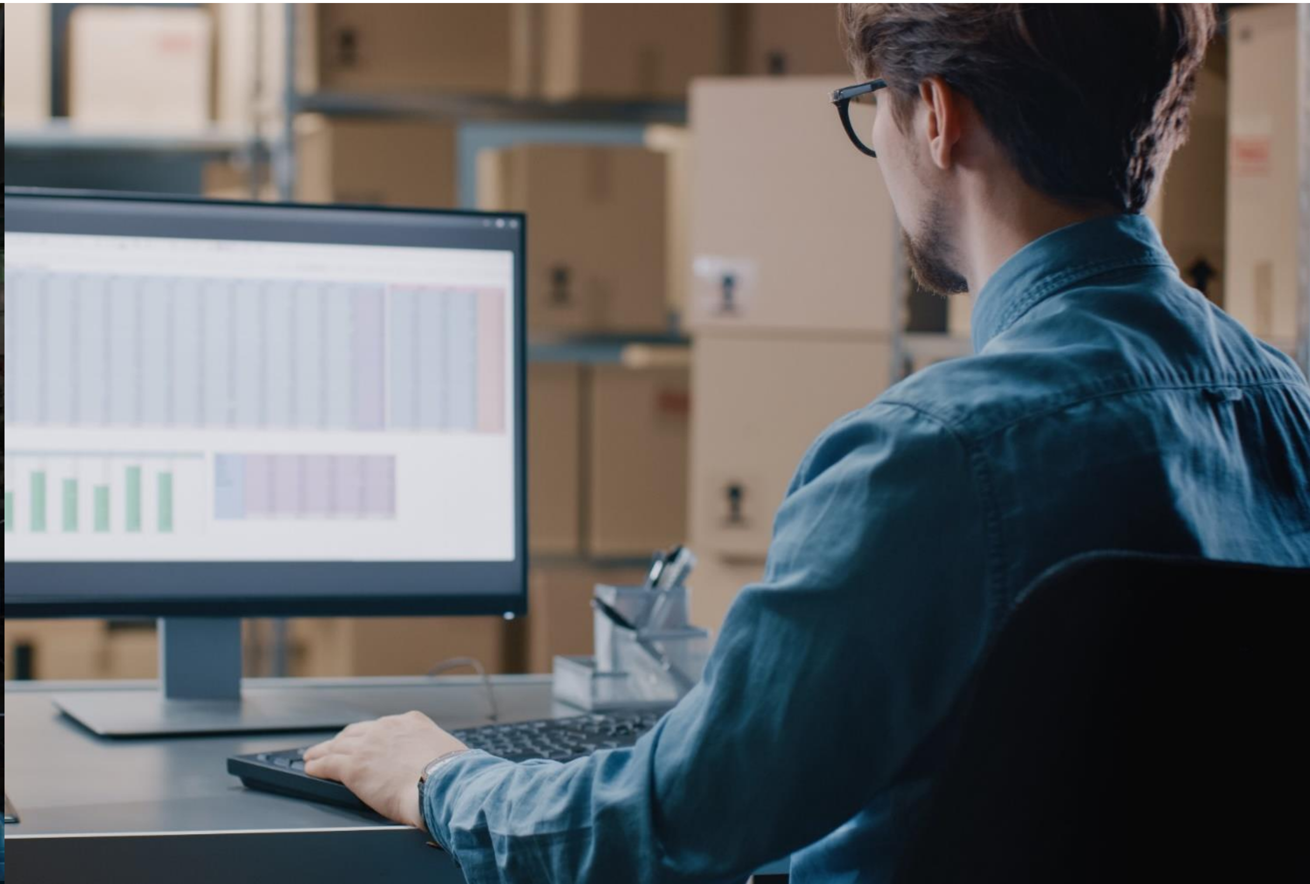
Pilot Projects

Gap Filling
- Abandoned wells
- Helicopter IR Survey

Synthesis Projects
- NETL LCA
- Synthesis

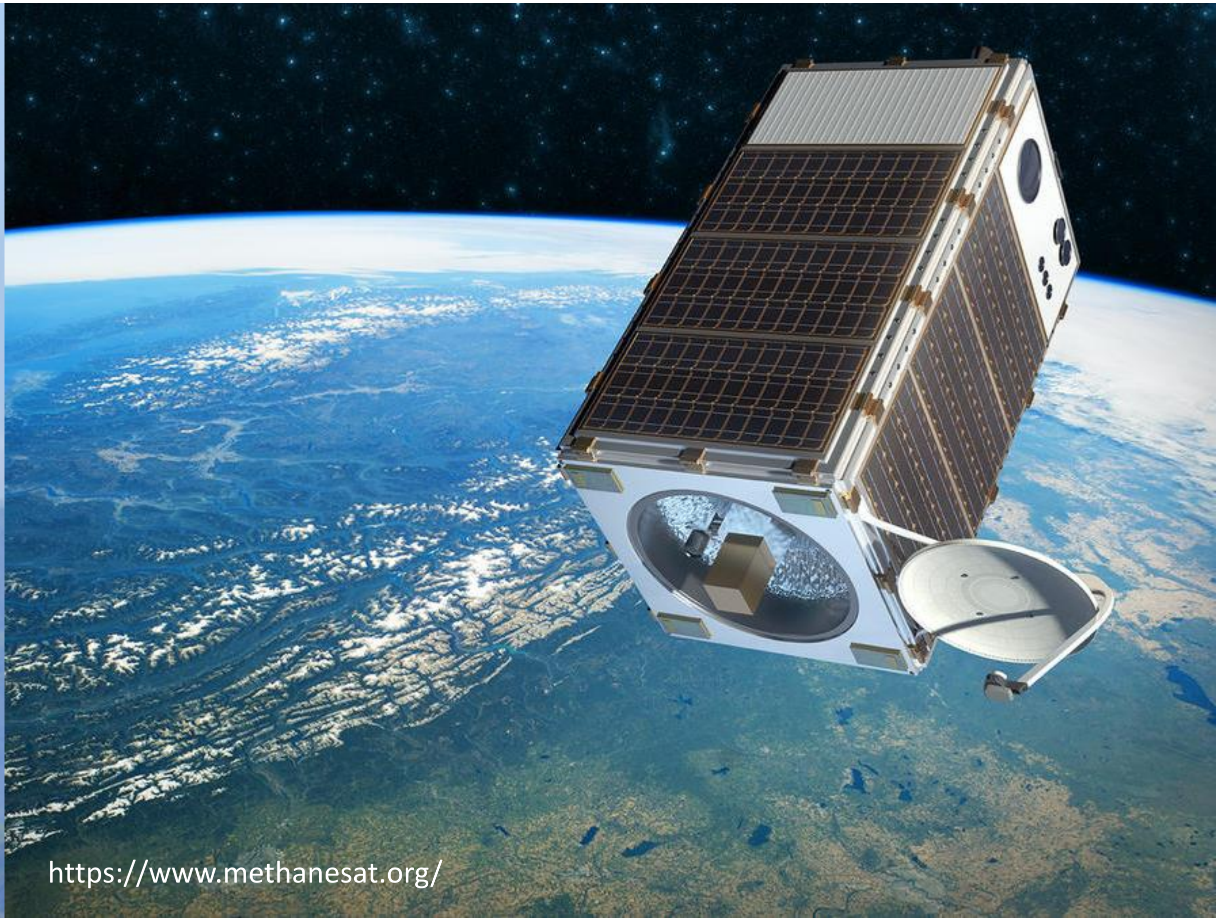
https://www.edf.org/climate/methane-research-series-16-studies

Bottom-up approaches estimate source-level emissions with activity data, emission factors, and engineering equations.



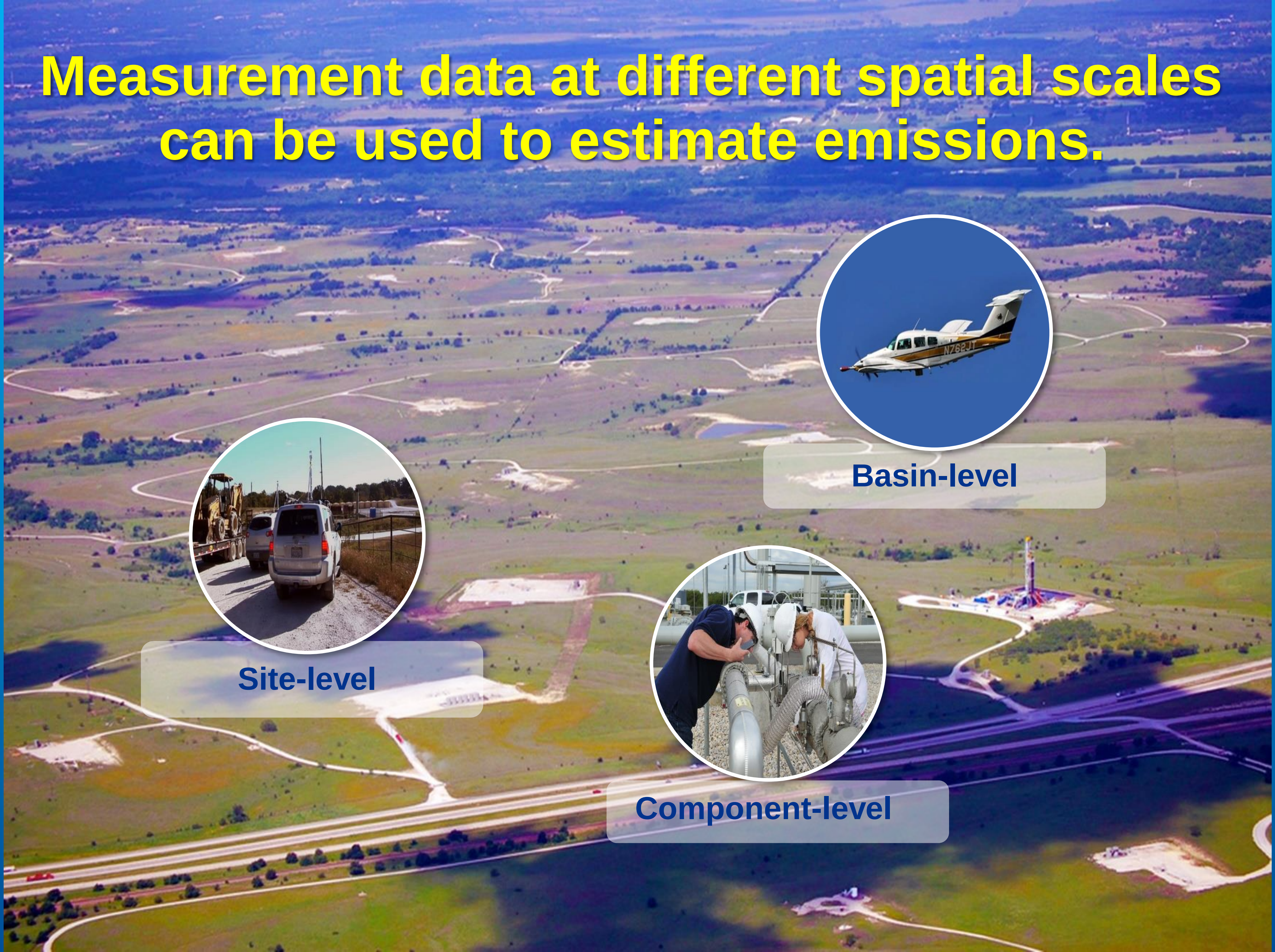
Top-down approaches estimate total emissions at large spatial scales with atmospheric measurements.

Photo credit: Scientific Aviation



https://www.methanesat.org/

Measurement data at different spatial scales can be used to estimate emissions.



U.S. O&G CH_4 studies were synthesized in Alvarez et al 2018

Science *REPORTS*

10.1126/science.aar7204

Cite as: R. A. Alvarez *et al*., *Science* 10.1126/science.aar7204 (2018).

Assessment of methane emissions from the U.S. oil and gas supply chain

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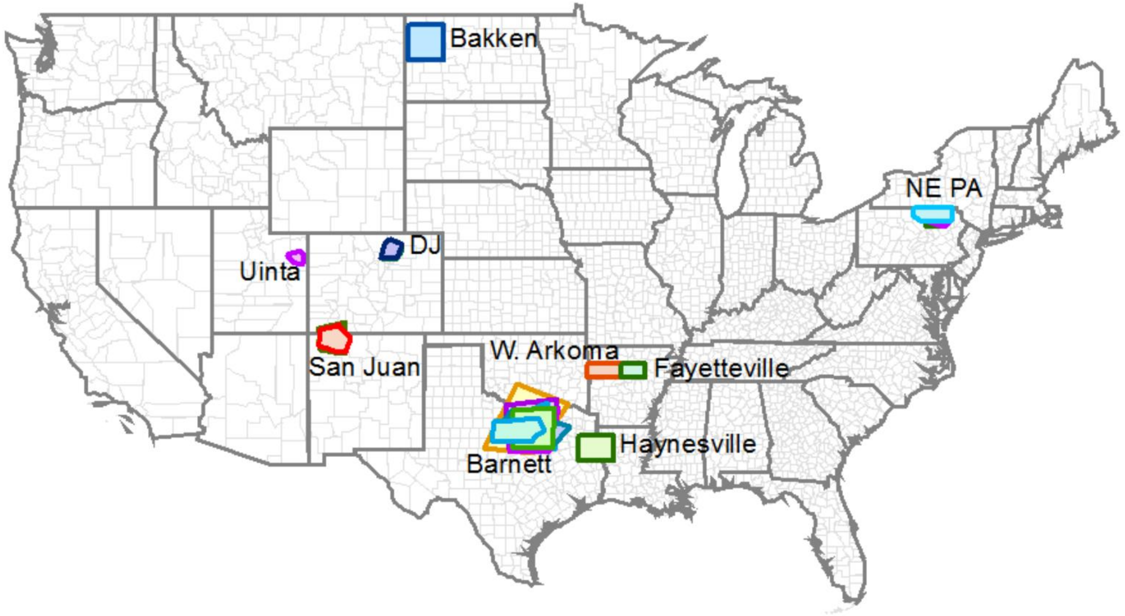
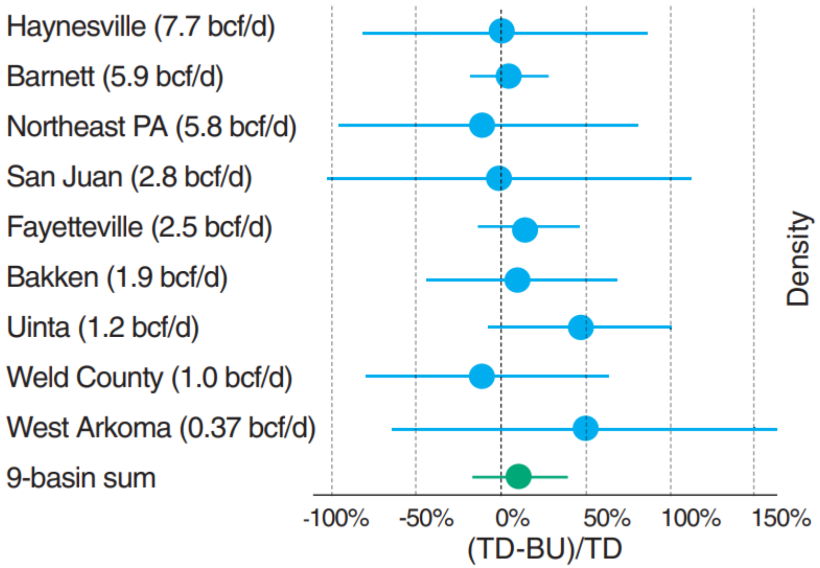
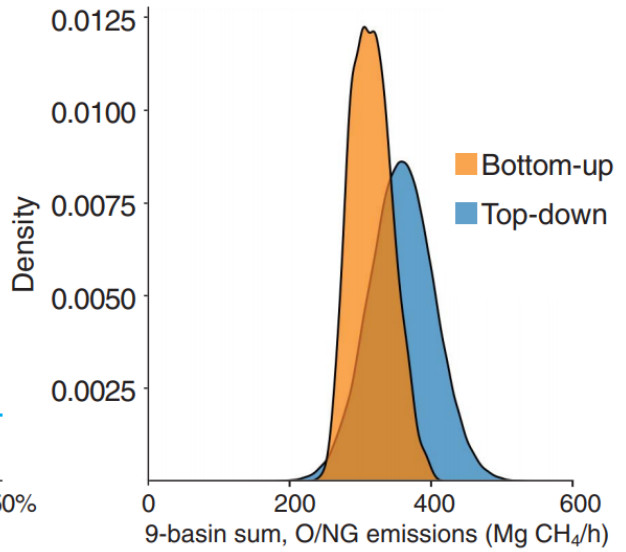
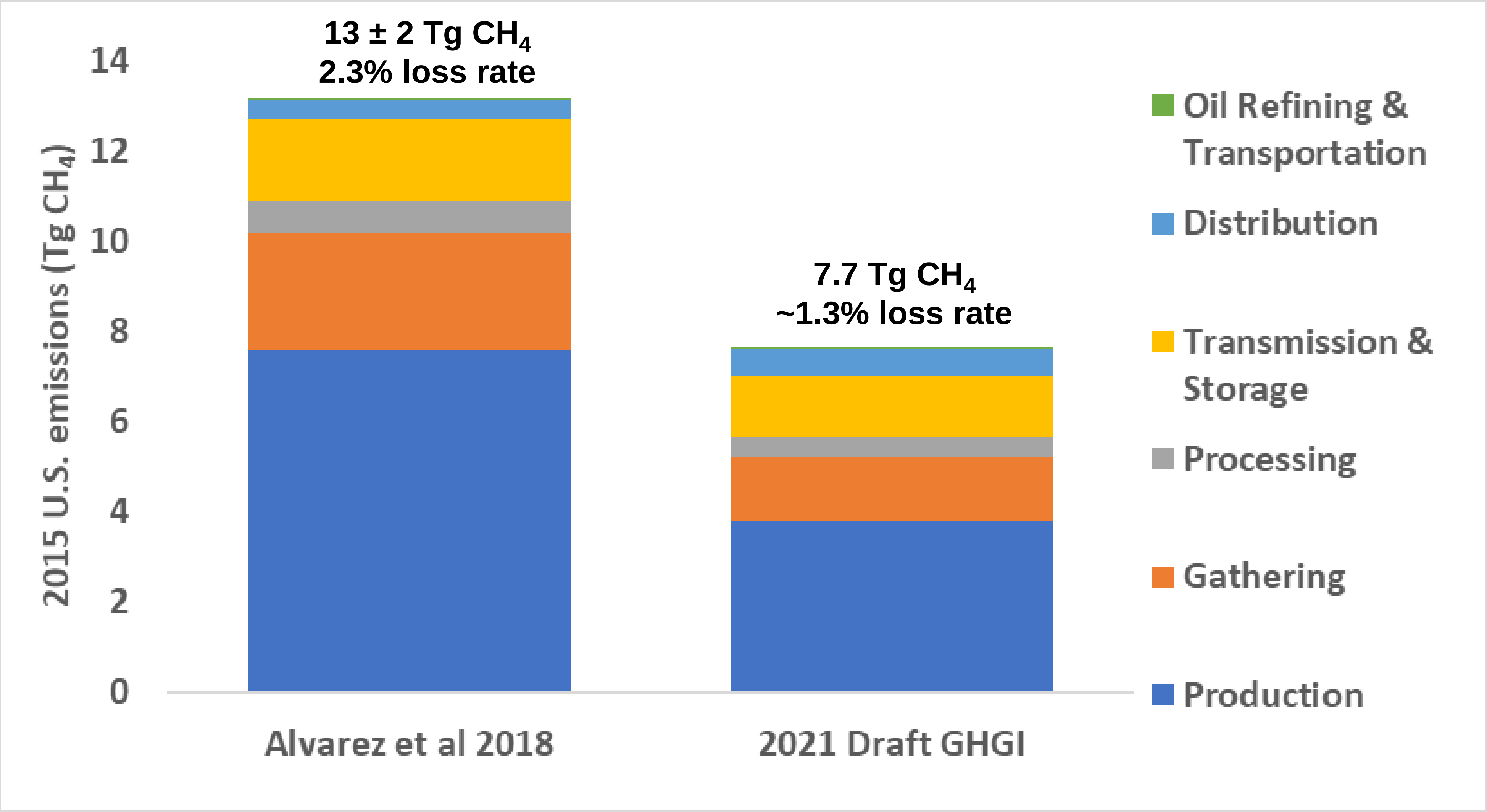




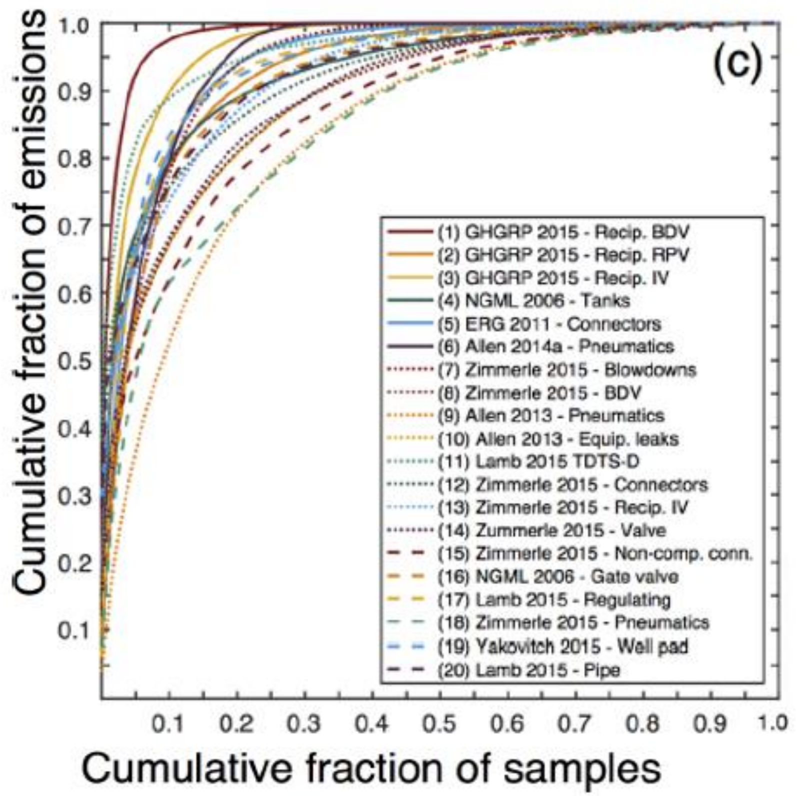


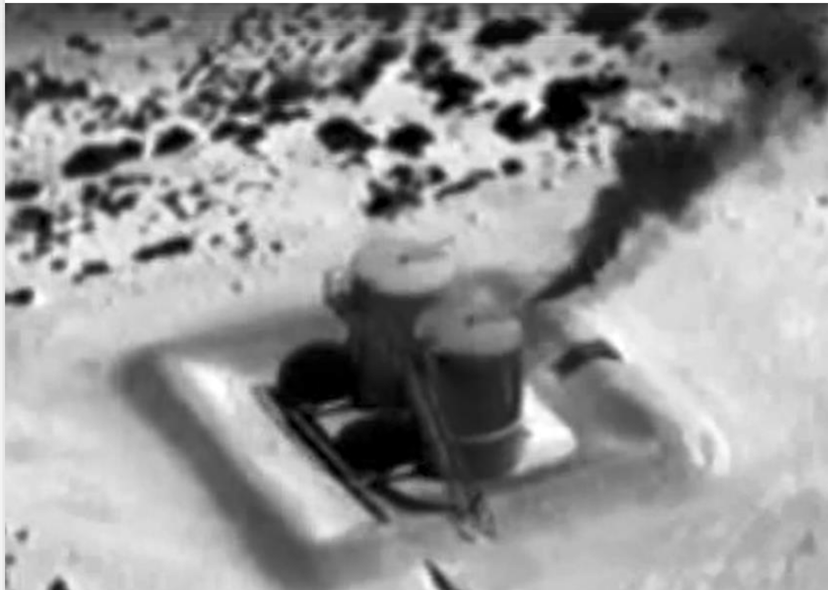
U.S. O&G CH_4 emissions are ~70% higher than current EPA estimates



Why do bottom-up approaches underestimate emissions?

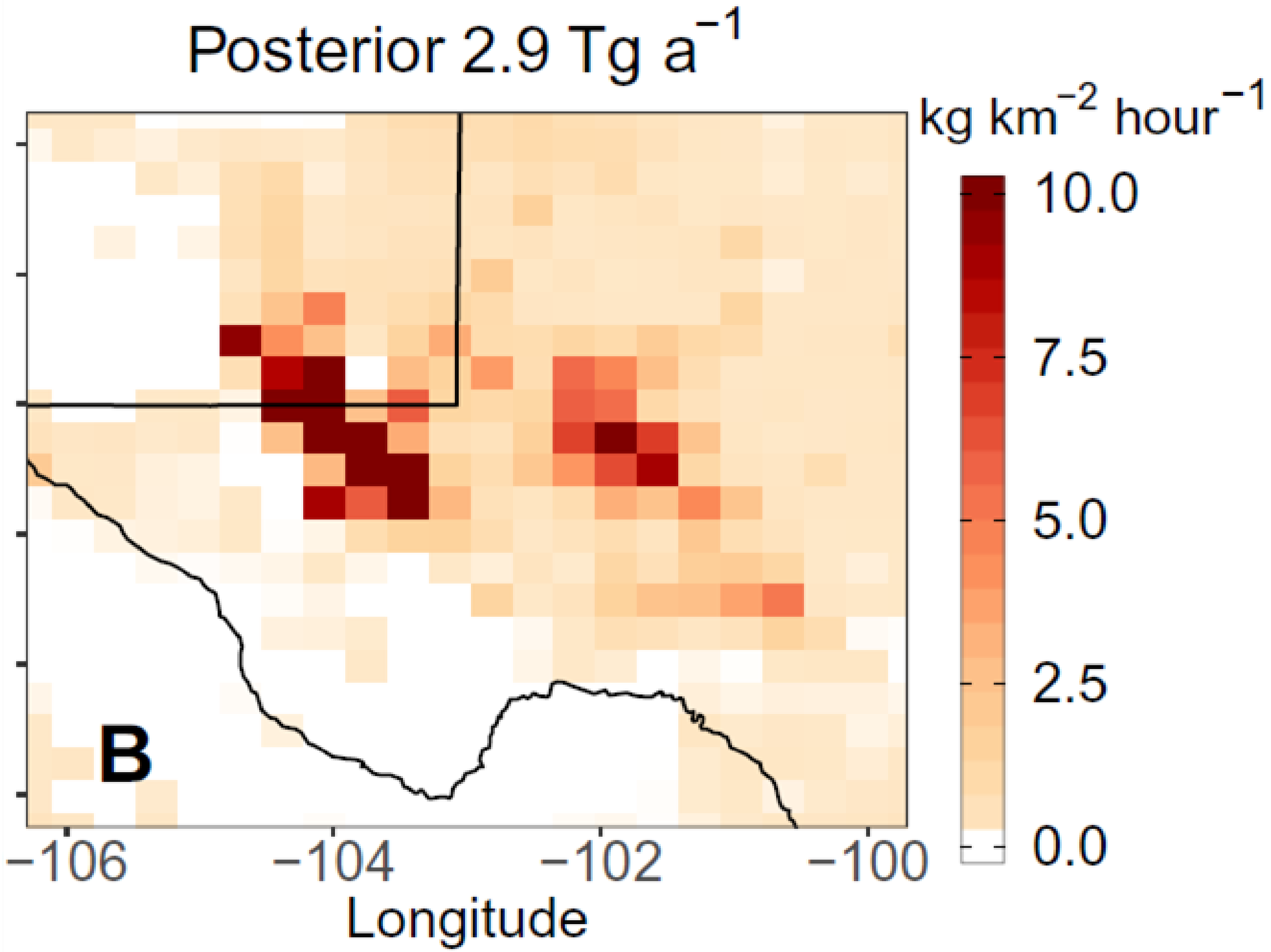
- Uncertain activity data
- Highly skewed emission rate distributions
- Episodic large emission events
- Large emissions are difficult to measure at the component-level






PermianMAP
Methane Analysis Project
Going deep into the world's largest oilfield
to track methane pollution

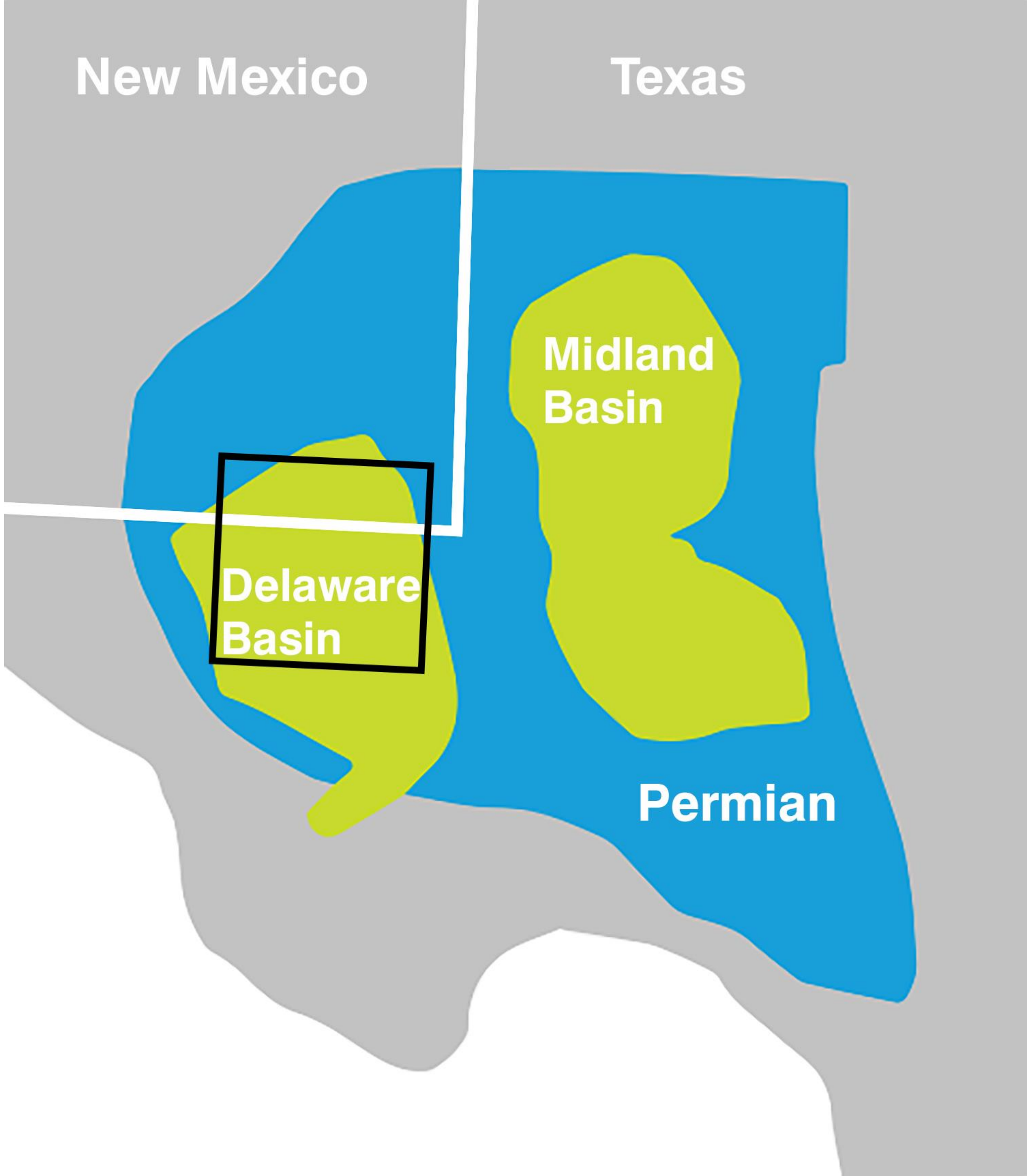
Satellite data indicate Permian Basin emissions are higher than U.S. average



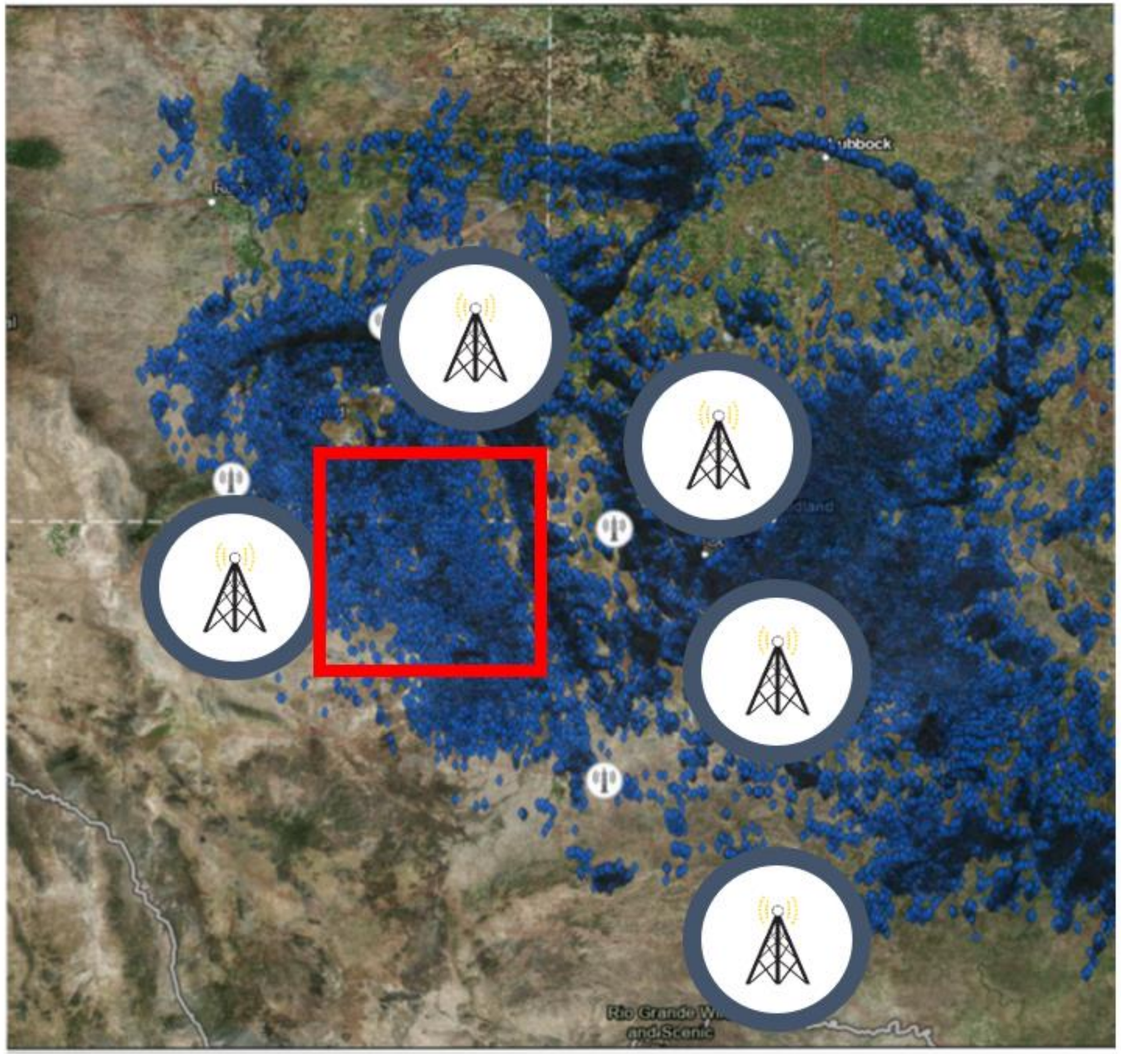
- Permian Basin CH_4 emissions estimated with May 2018 – March 2019 TROPOMI data
- 3.7% loss rate and highest emissions of any U.S. basin
- Published in *Science Advances* (Zhang et al 2020)
  - https://advances.sciencemag.org/content/6/17/eaaz5120

Permian Study Area

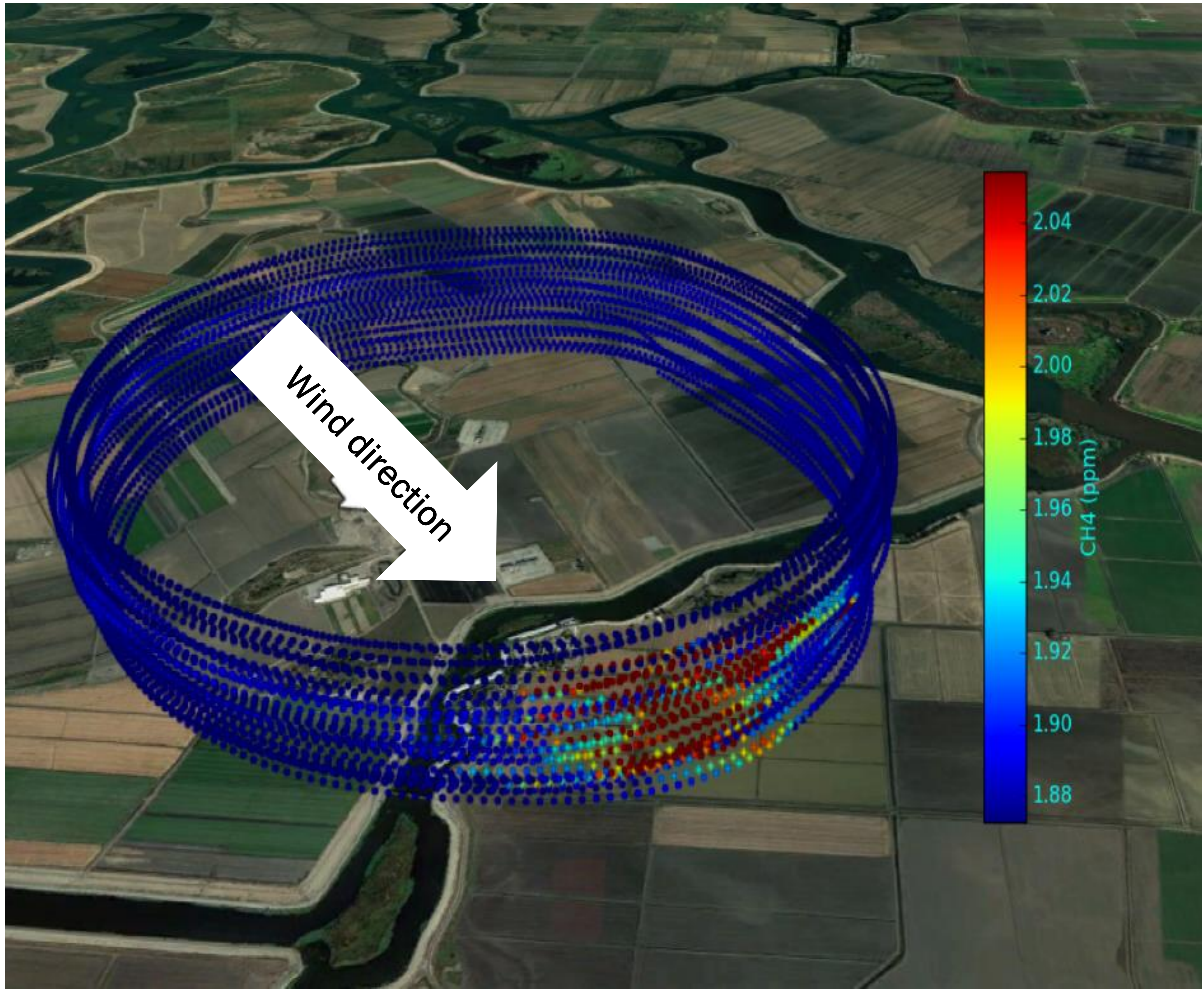
- 10,000 km^2 area of the Delaware Sub-Basin in Texas and New Mexico
- High production area accounts for ~10% of wells and one-third of O&G production from Permian Basin
- Over 100 different companies operate nearly 11,000 wells
- We also are collecting data in the Midland Sub-Basin.



Penn State: Tower-based, weekly estimates of study area CH_4 emissions since March 2020



Scientific Aviation: ~100 flight days quantifying emissions from study area and multi-site areas



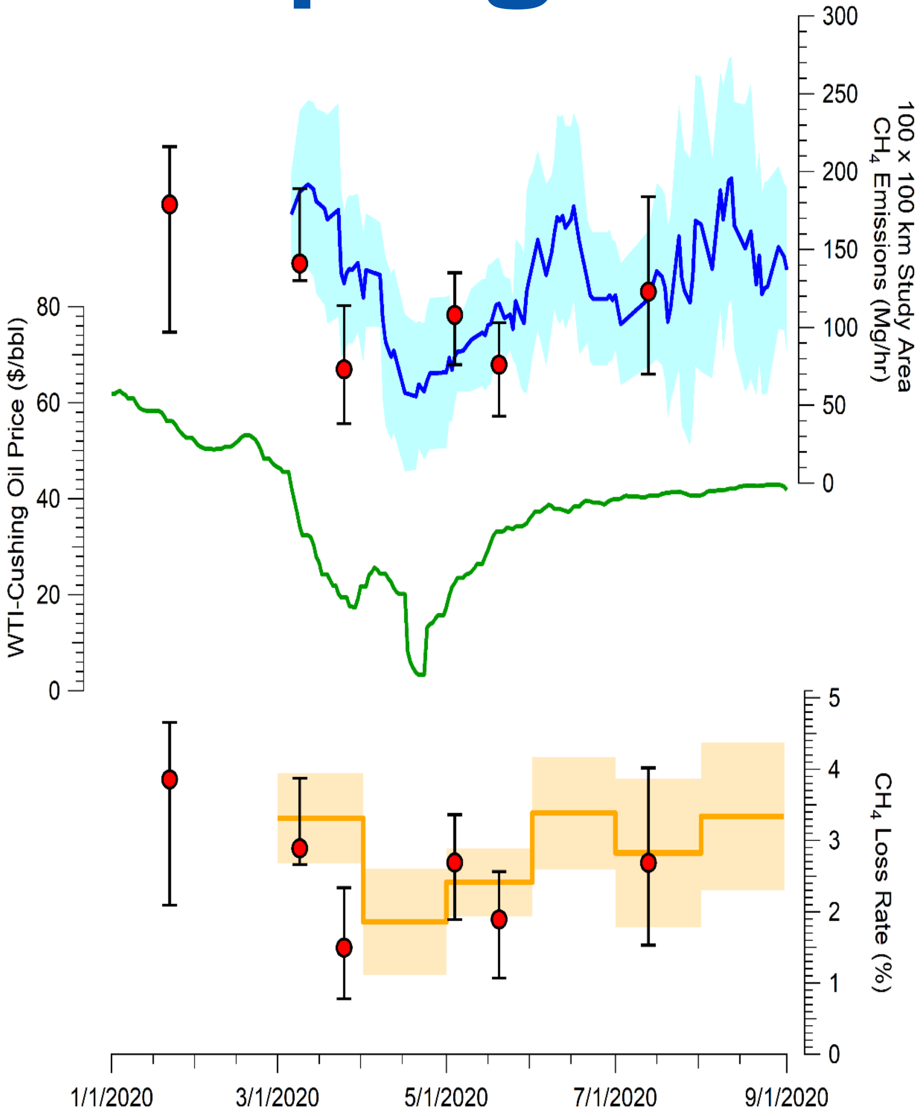
U. Wyoming: Vehicle-based estimates of site-level methane & VOC emissions

LSI: helicopter-based infrared optical gas imaging surveys of flare performance

Permian study area emissions temporarily declined when oil price crashed in spring 2020

The study area loss rate changed from 3.3 to 1.9% during low oil price conditions then returned to near pre-crash levels. Likely causes of the temporary decline are:

- Lower well development rates
- Reduced flared gas volumes
- Less abnormal emission events from gathering system issues such as over-pressurization



Paper accepted: https://acp.copernicus.org/preprints/acp-2020-1175/

Large, intermittent sources are numerous

- >10 metric ton per hour CH_4 source detected at gathering compressor station during aerial survey
- Total emissions ≈ 300 tons CH_4 based on 4 aerial measurements and company-reported duration
- Operator reported to Texas CEQ emergency VOC venting caused by compressor engine failure
- Other groups have detected many similar sources with remote sensing

Photo credit: Scientific Aviation

Marginal well emissions are substantial

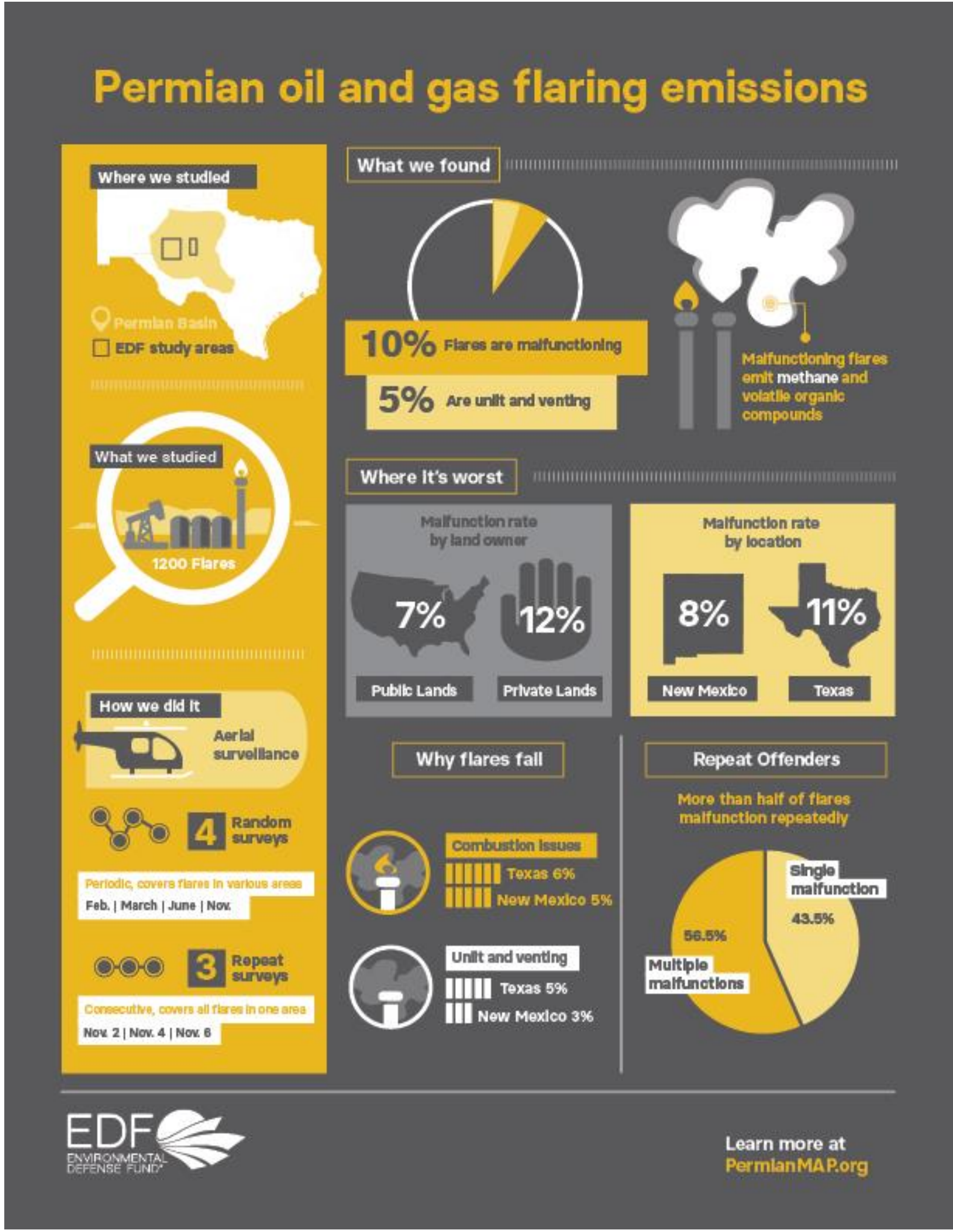
- Well pad emission rates are highly skewed.
  - ~70% of sites below 0.3 TPY detection limit
  - Top 15% highest emitting sites responsible for 70% of emissions
  - Much higher emissions from well pads with tanks or compressors.
  - https://doi.org/10.1021/acs.est.0c02927
- Marginal well pads have high loss rates and account for about half of Permian well pad emissions.
- Similar findings in other basins
  - https://pubs.acs.org/doi/10.1021/acs.est.8b03535

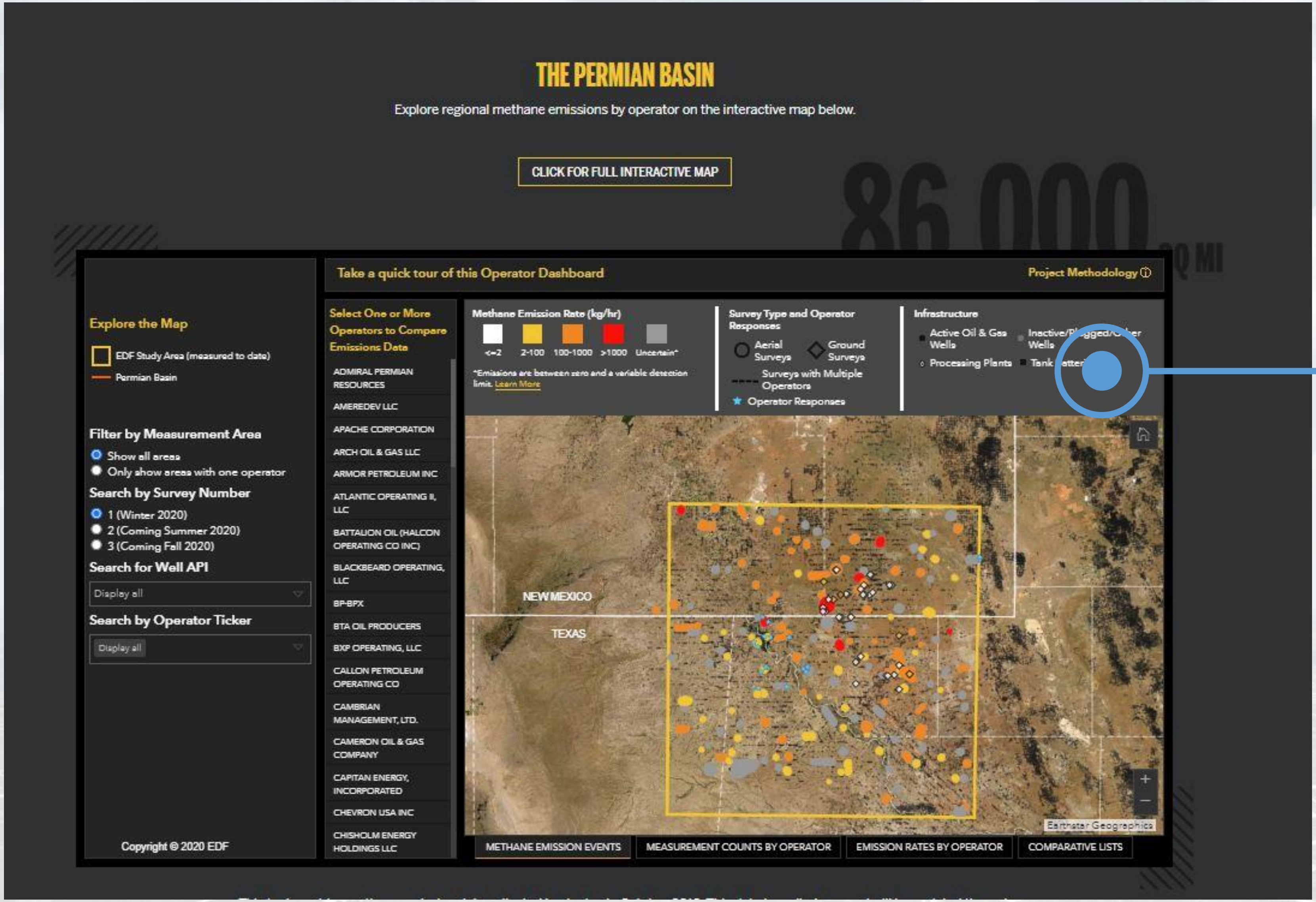
U. WY Data	Well Pad Type	Site-level average emission rate (TPY CH_4)	Average loss rate (% gas production)
Summer 2018 (~70 sites) Robertson et al 2020	Total	37	0.88%
	Simple	4.2	~0.3%
	Complex	85	~3%
2020 (~200 sites) **Preliminary: Do not cite**	Total	22	2.6%
	Simple	0.6	0.1%
	Complex	43	3.8%
	Marginal	**8**	**7.3%**
	Non Marginal	41	2.3%

Simple sites (~67% of Permian well pads) include a wellhead only.
Complex sites (~33%) include a tank and/or compressor.
Marginal sites (~75%) defined as <15 BOED recent production.

Malfunctioning flares are a large emission source

- >1200 Flares observed by aerial infrared surveys in Feb., March, June, and Nov. 2020
- Consistently, 5% of surveyed flares were unlit and venting and another 5% had combustion issues
- 57% of malfunctioning flares had repeat issues
- Survey results suggest Permian flares have mean combustion efficiency of ≤93% and contribute ≥10% of basin methane emissions





Delivering the Data

Videos, photos, and emissions data available for viewing and download at permianmap.org

PermianMAP: Relevance to New York

- Measurements can be used to quantify both in-state and upstream out-of-state methane emissions.

- Top-down approaches currently can quantify basin-level loss rates but there are remaining challenges to differentiate performance among operators.

- Marginal wells tend to have lower absolute emissions, but higher loss rates than higher production wells.

Local Distribution Emissions

- EDF has partnered with Google Earth Outreach, Colorado State University, and utilities on advanced pipeline leak detection and quantification.
  - https://www.edf.org/climate/methanemaps
- Mobile approaches find more leaks and estimate higher emissions than traditional surveys.
  - https://pubs.acs.org/doi/abs/10.1021/acs.est.0c00437
- Data helped Con Edison double their methane mitigation by prioritizing repair of the largest leaks.
  - https://www.edf.org/climate/methanemaps/con-edison

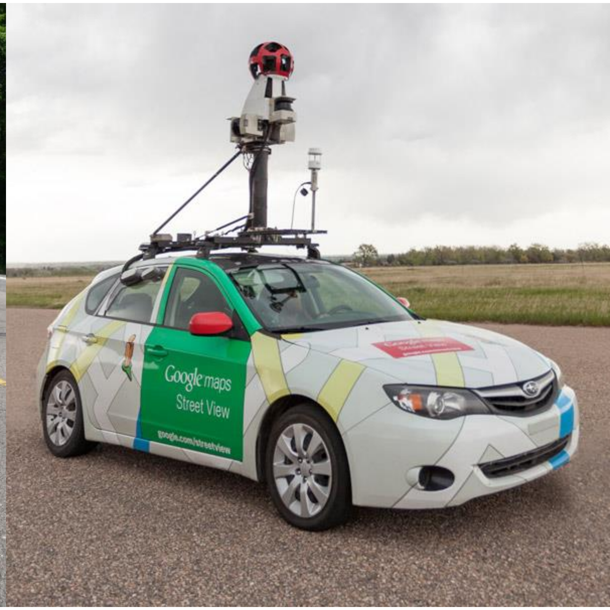
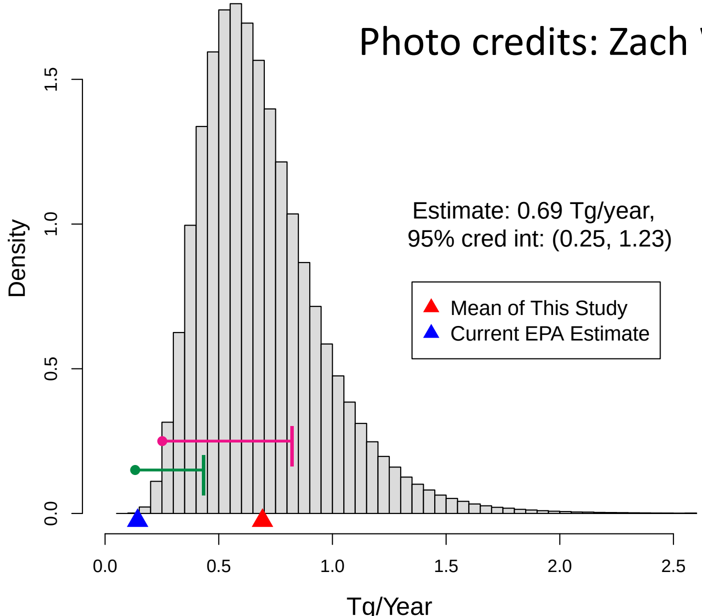


Photo credits: Zach Weller



Questions?

Methane hunters Dr. David Lyon (EDF) and Dr. Anna Robertson (U. of Wyoming)

LESLIE VON PLESS / EDF