A new paradigm of measurement based emission inventories

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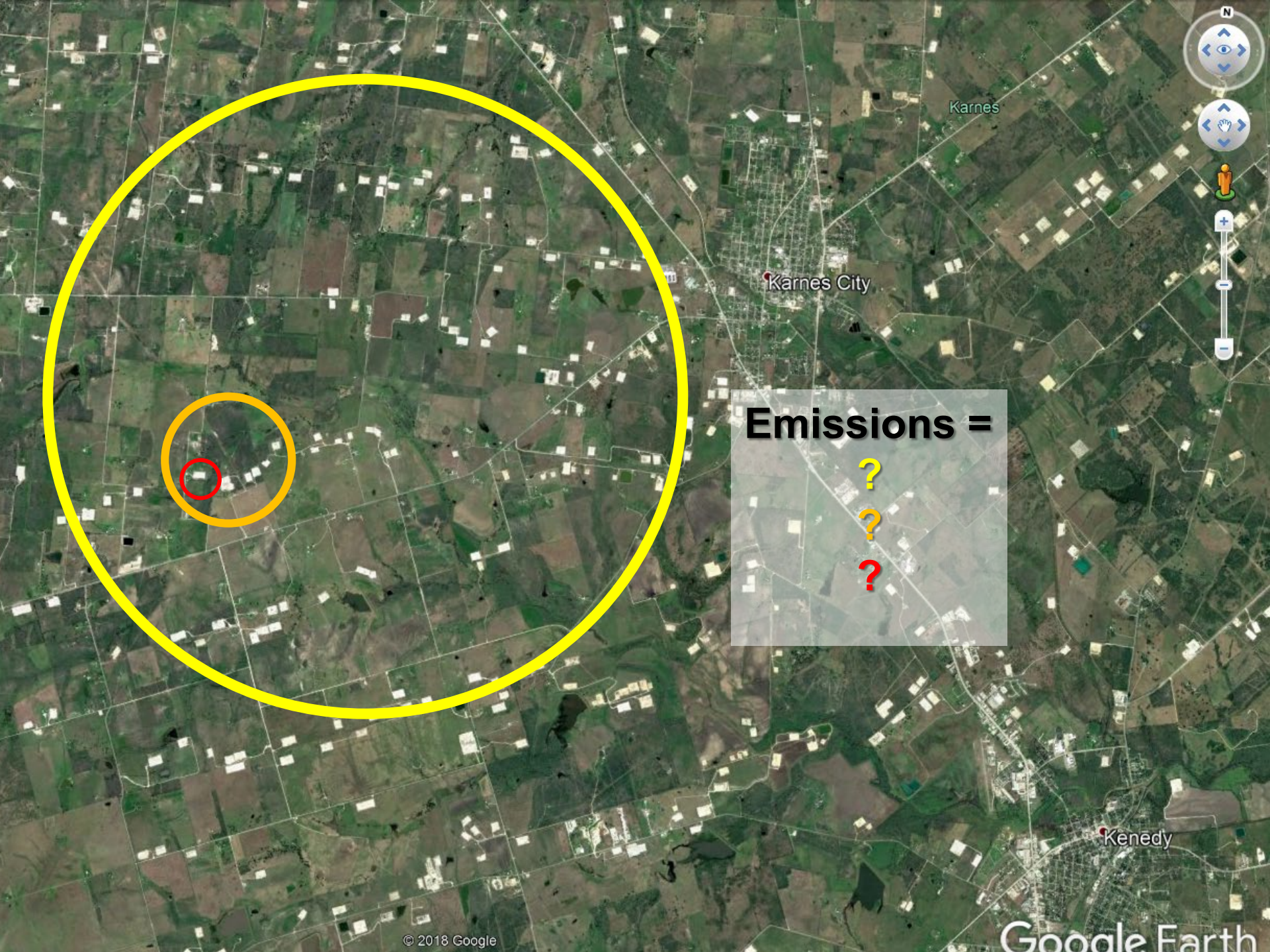
Karnes
Karnes City
Kenedy
Emissions =
?
?
?
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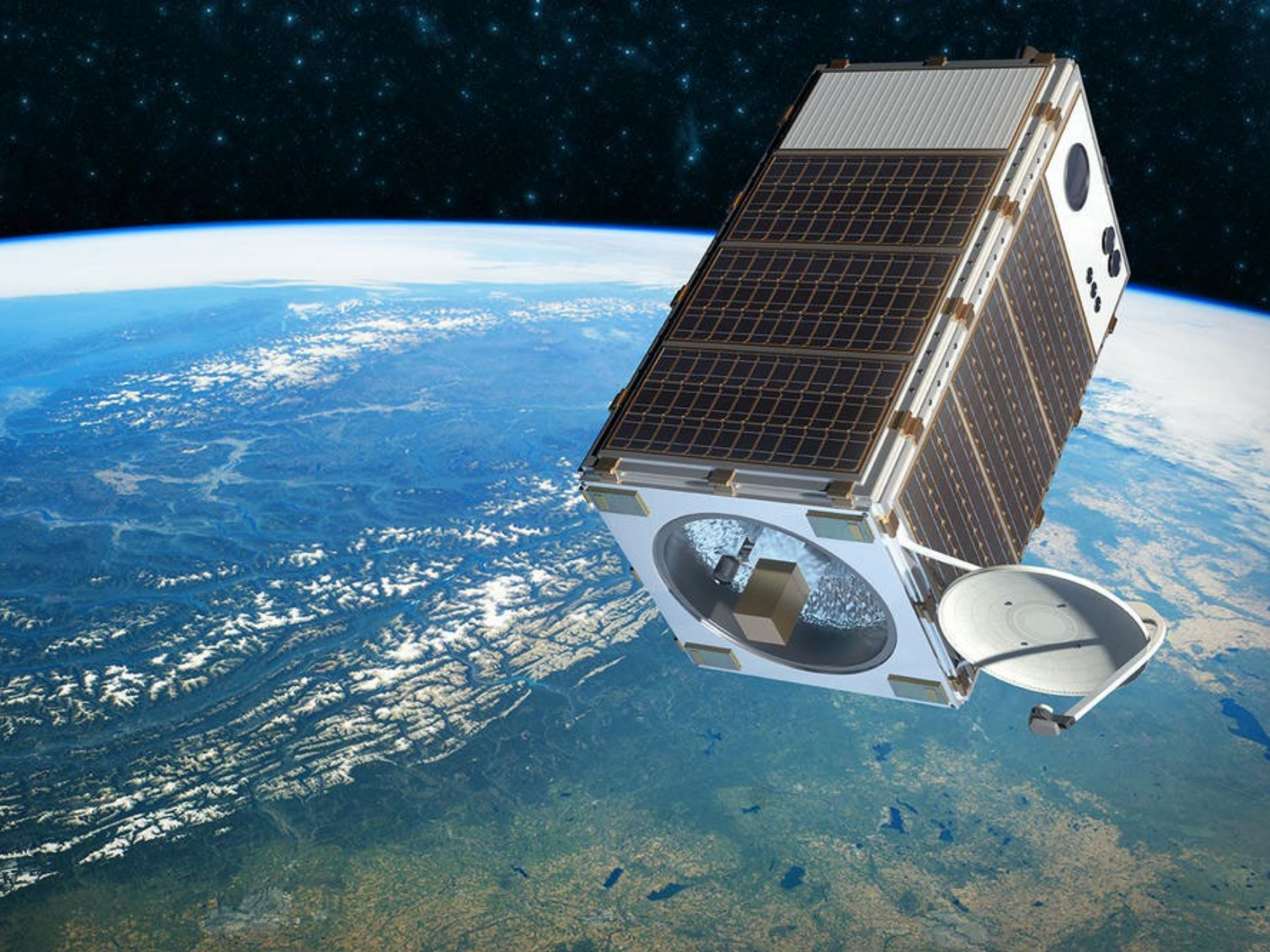
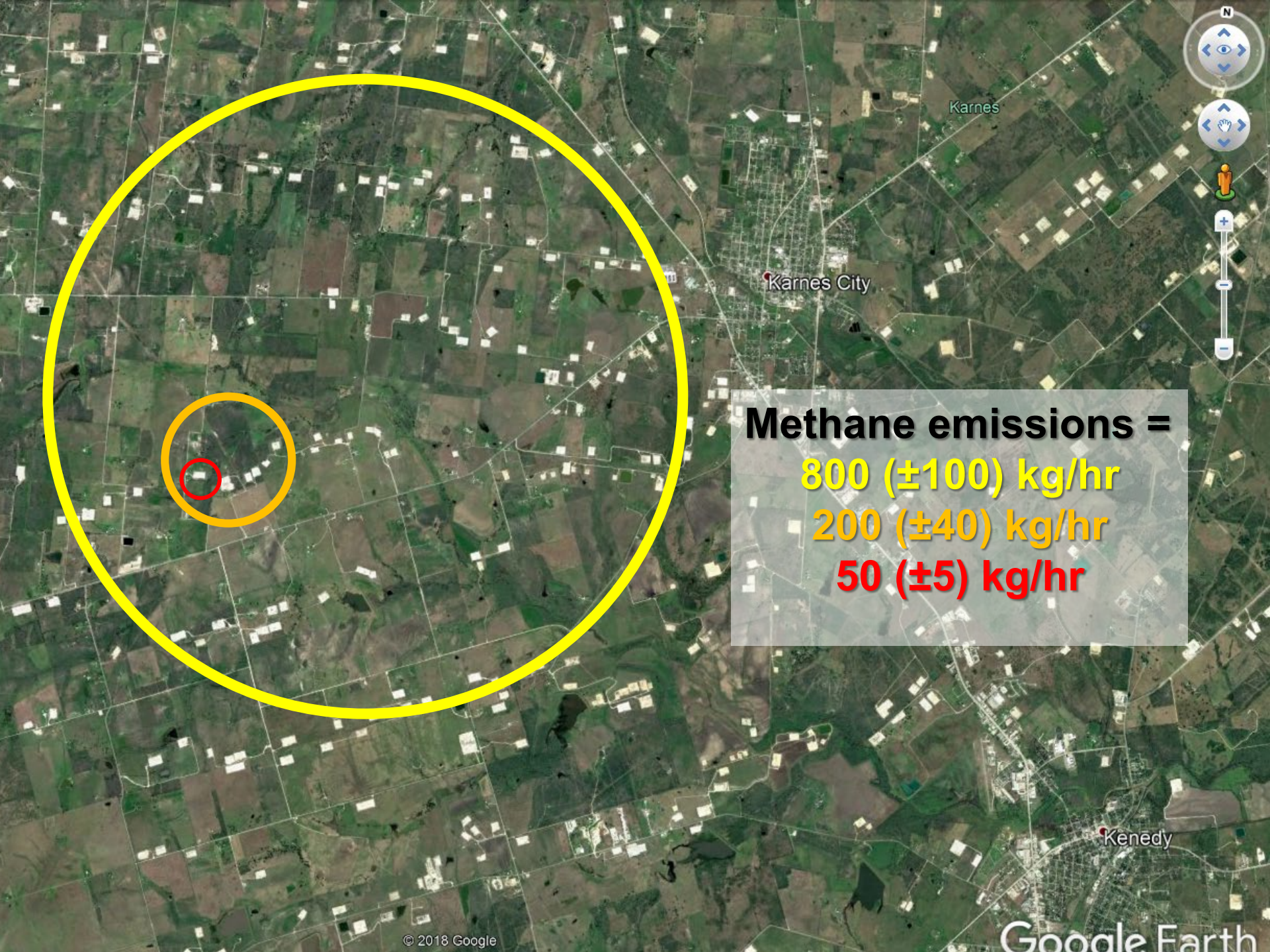
Google Earth

Photo: University of Wyoming

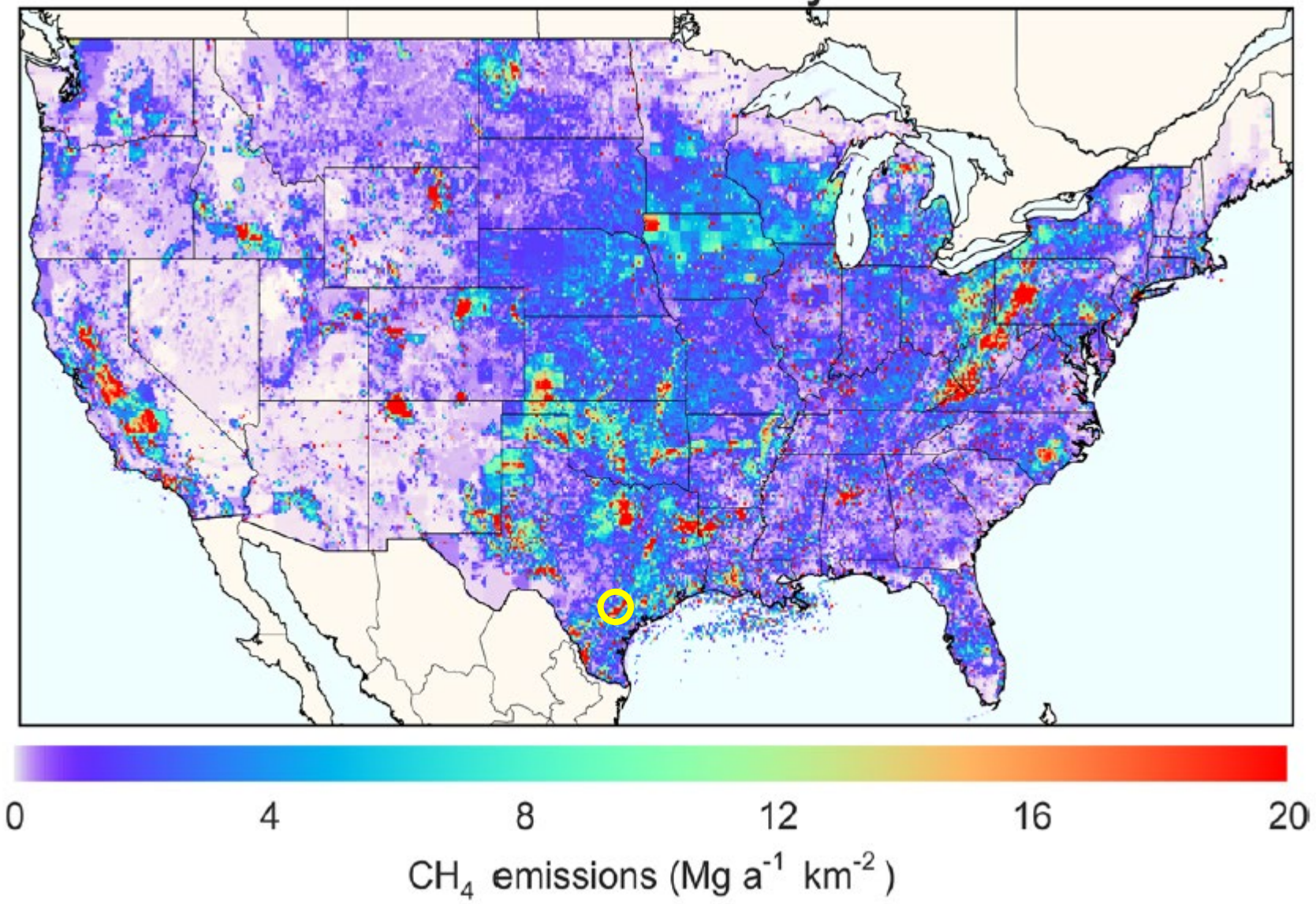
Photo: Scientific Aviation




3.5
4.8
5.0
5.0
6.0
4.6
3.3
2.3
2.2
3.5
2.4
1.8
2.5
5.2
6.9
6.7
6.8
9.2
5.4
5.6
3.9
6.5


Karnes
Karnes City
Kenedy
Methane emissions =
800 (±100) kg/hr
200 (±40) kg/hr
50 (±5) kg/hr
© 2018 Google
Google Earth

Gridded EPA Inventory for 2012



https://pubs.acs.org/doi/abs/10.1021/acs.est.6b02878

Outline

- Background
- EDF oil and gas methane studies
- Traditional paradigm for nonpoint inventories
- Lessons learned from O&G CH_4 research
- New measurement based paradigm
- Ongoing work

- ~700 staff in 12 offices worldwide
- >2.5 million members and activists
- Nonpartisan & nonprofit
- Guided by science and economics
- Core values of Results, Respect, Innovation, Optimism, and Integrity

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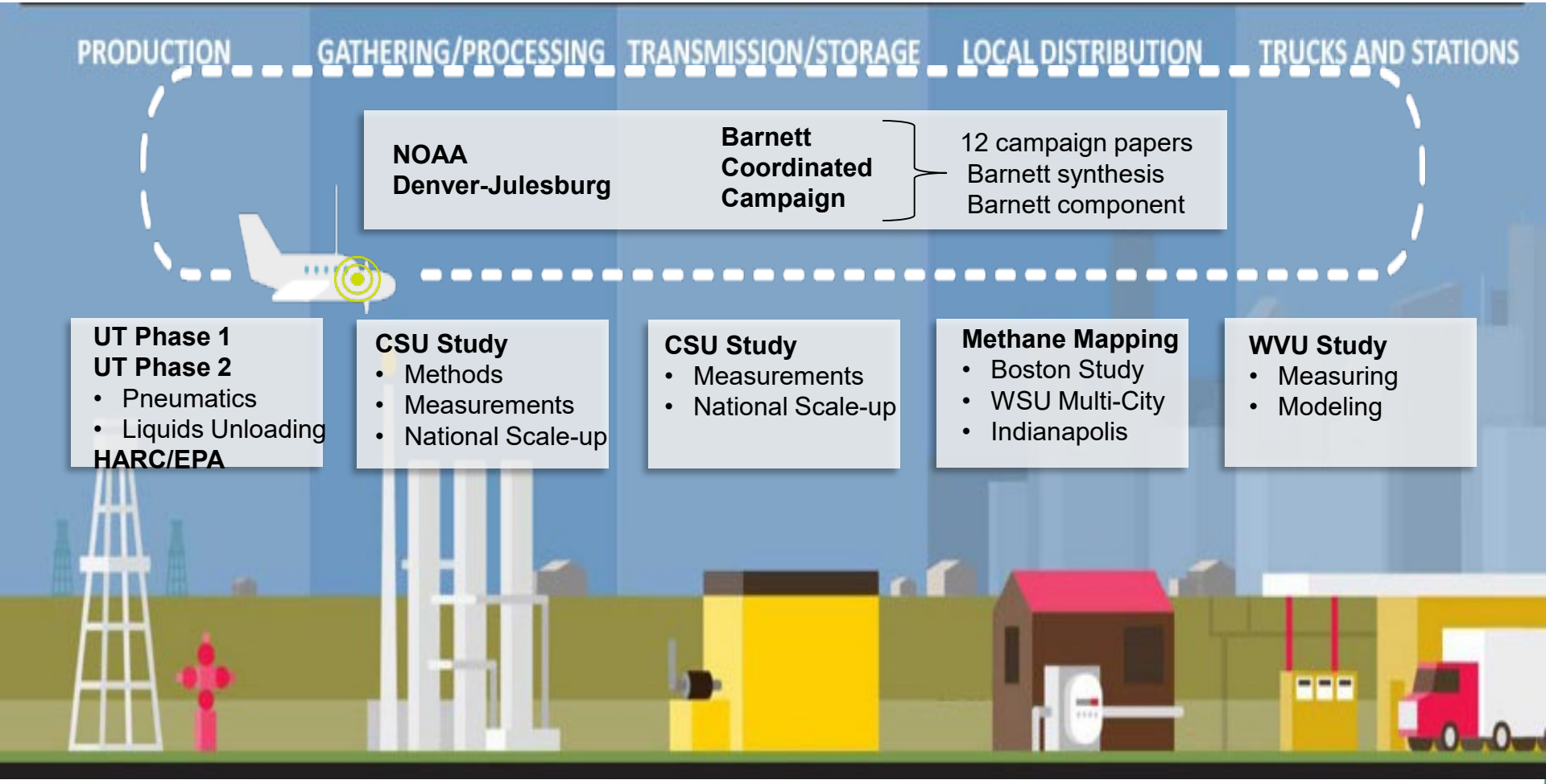
EDF U.S. Oil & Gas CH_4 Studies



Pilot Projects

Gap Filling
- Abandoned wells
- Helicopter IR Survey

Synthesis Projects
- NETL LCA
- Synthesis

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

EDF's Methane Research

Rigorous Science

Studies employ independent experts and use multiple methods to measure methane emissions

Broad Collaboration

More than 130 co-authors from 50 research institutions and 50 O&G companies

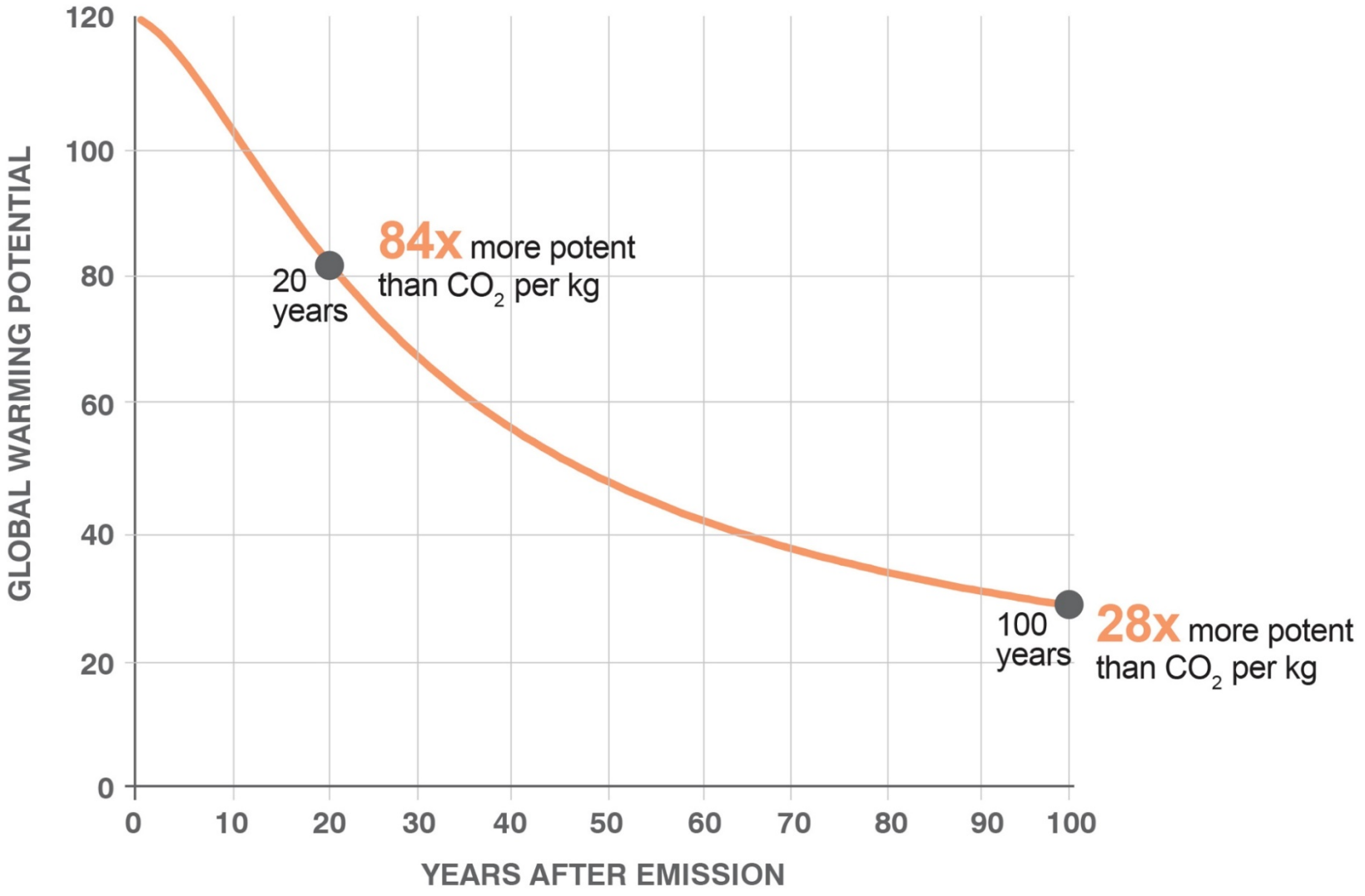
Transparent Results

38 peer-reviewed manuscripts and publicly available data

Collaborative partnerships to advance science and policy

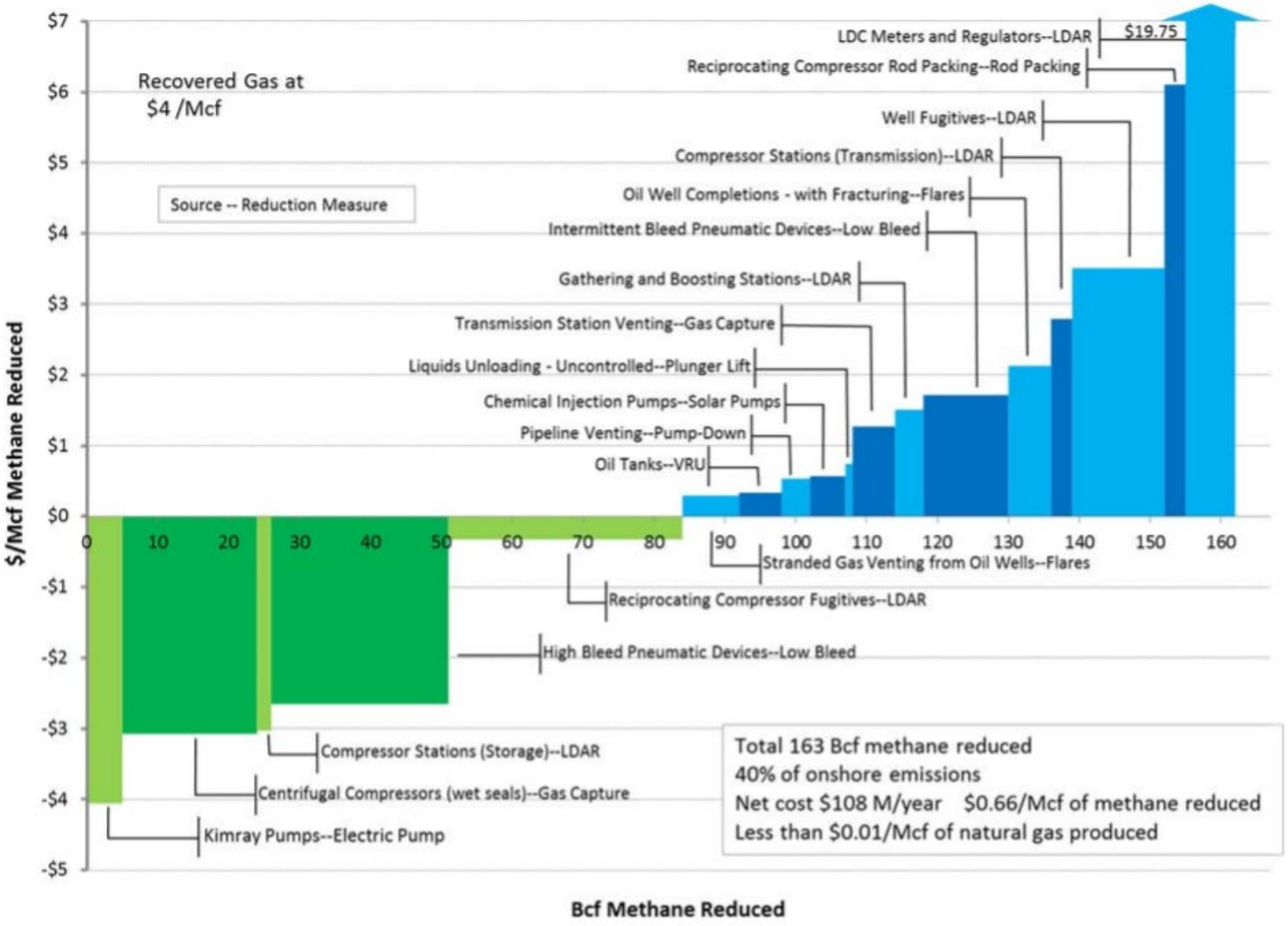

Why O&G methane emissions?

Methane is a powerful greenhouse gas.



O&G CH_4 mitigation is cost-effective.

Figure 1-1 - Marginal Abatement Cost Curve for Methane Reductions by Source



https://www.edf.org/sites/default/files/methane_cost_curve_report.pdf

O&G infrastructure is diverse, widespread, and emits multiple pollutants from numerous sources.

Point

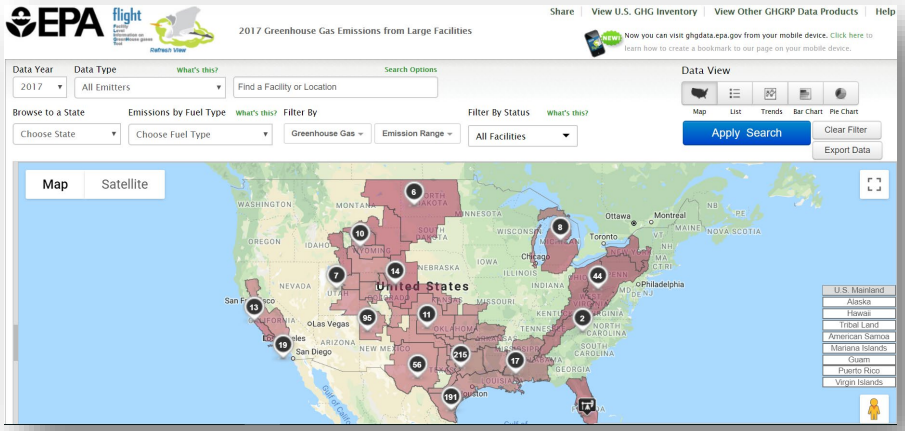
Nonpoint

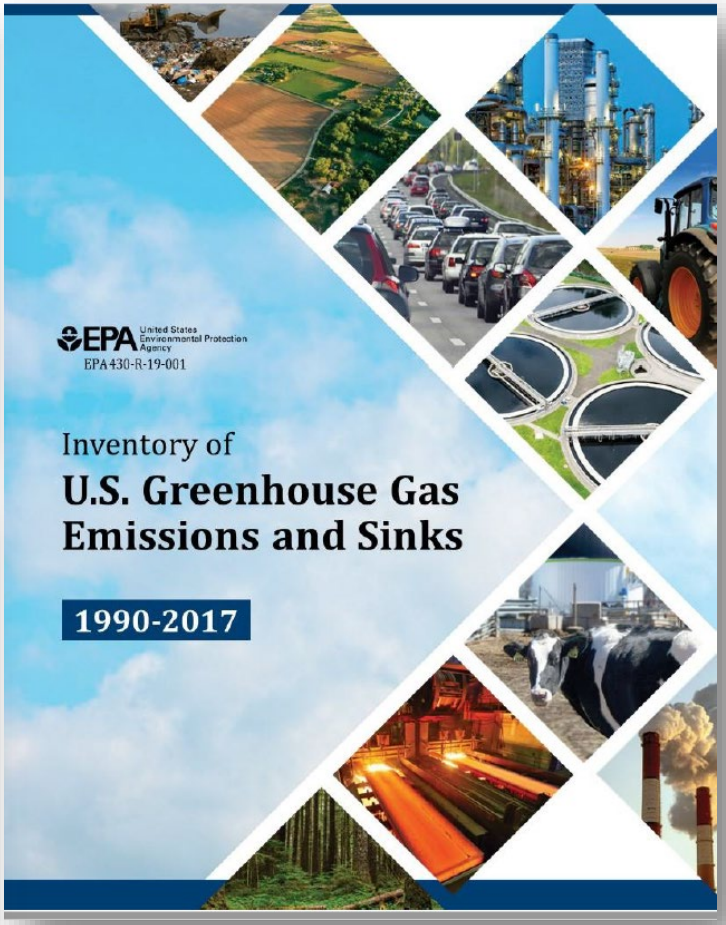
Nonroad

Onroad

[Event]

What is the traditional paradigm for estimating nonpoint source emissions?



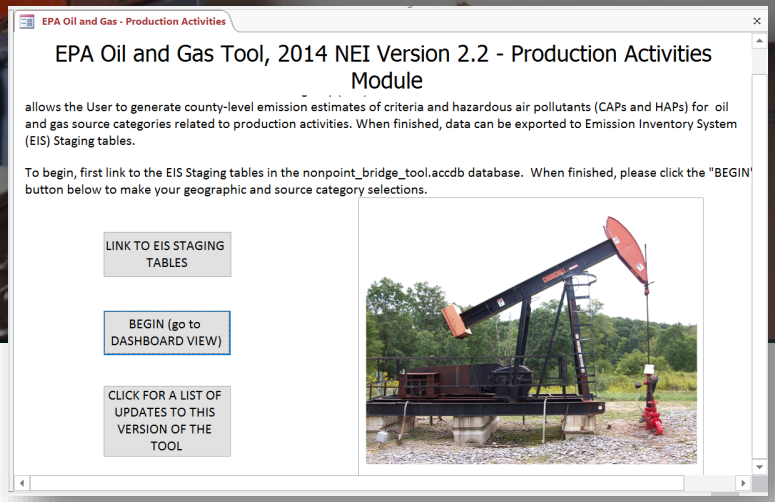


The general equation for emission estimation is:

$E = A \times EF \times (1-ER/100)$

where:

- E = emissions
- A = activity rate
- EF = emission factor
- ER = overall emission reduction efficiency, %



https://gispub.epa.gov/neireport/2014/

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

Basin-level

Site-level

Component-level

We used an alternative, measurement based approach to quantify O&G CH_4 emissions.

- Synthesis paper integrates several recently published datasets to quantify 2015 U.S. emissions
  - Production segment emissions estimated with site-level measurements from 6 basins
  - Regional emissions validated with aerial, basin-level measurements from 9 basins
  - Empirical estimates compared to traditional inventories

Drilling & Production

Gathering & Processing

Transmission & Storage

Local Distribution

Regional Research

Science

REPORTS

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

Ramón A. Alvarez[1]*, Daniel Zavala-Araiza[1], David R. Lyon[1], David T. Allen[2], Zachary R. Barkley[3], Adam R. Brandt[4], Kenneth J. Davis[3], Scott C. Herndon[5], Daniel J. Jacob[6], Anna Karion[7], Eric A. Kort[8], Brian K. Lamb[9], Thomas Lauvaux[3], Joannes D. Maasakkers[6], Anthony J. Marchese[10], Mark Omara[1], Stephen W. Pacala[11], Jeff Peischl[12,13], Allen L. Robinson[14], Paul B. Shepson[15], Colm Sweeney[13], Amy Townsend-Small[16], Steven C. Wofsy[6], Steven P. Hamburg[1]

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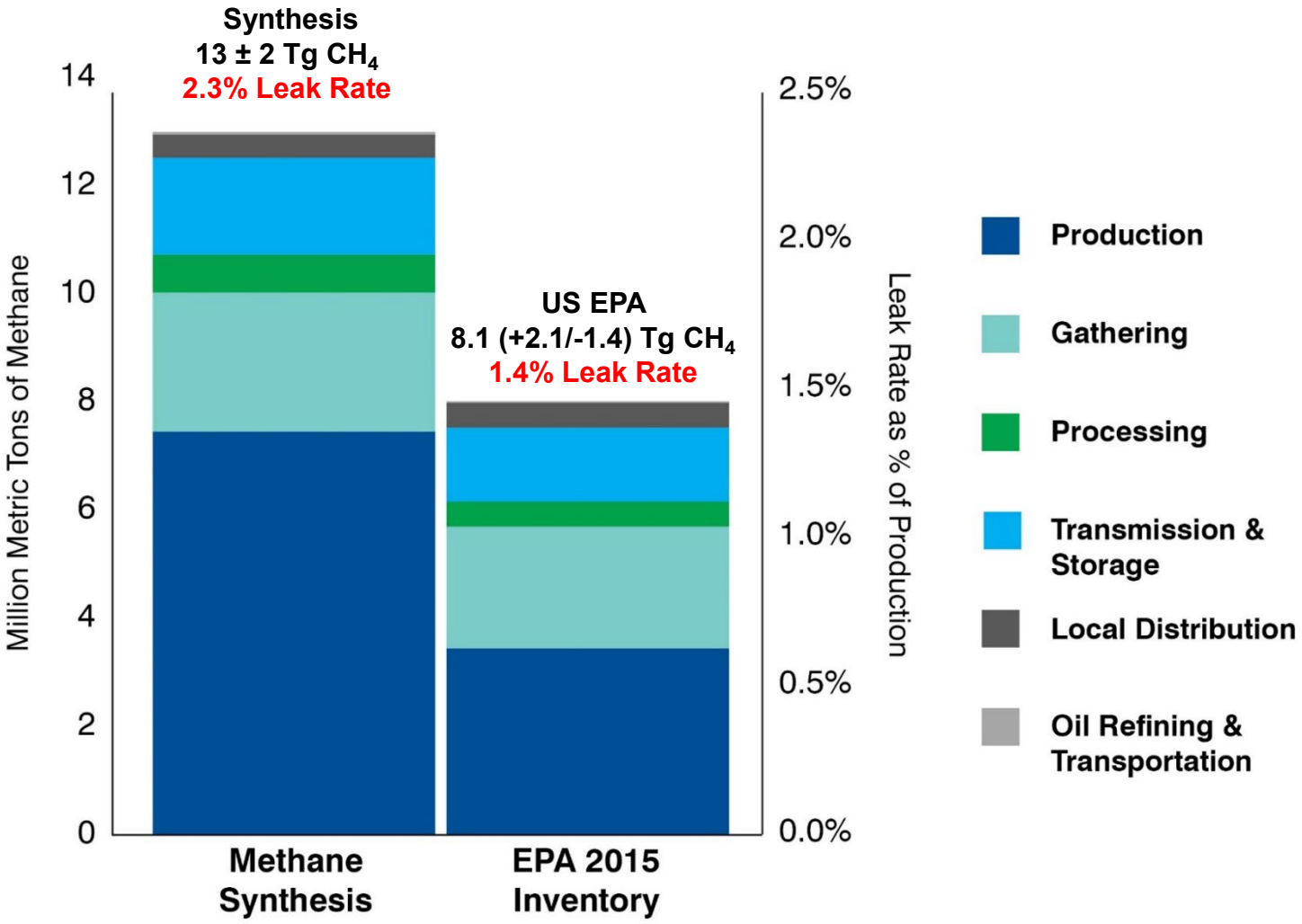
Manuscript and supplementary materials published June 2018 in *Science*
DOI: 10.1126/science.aar7204

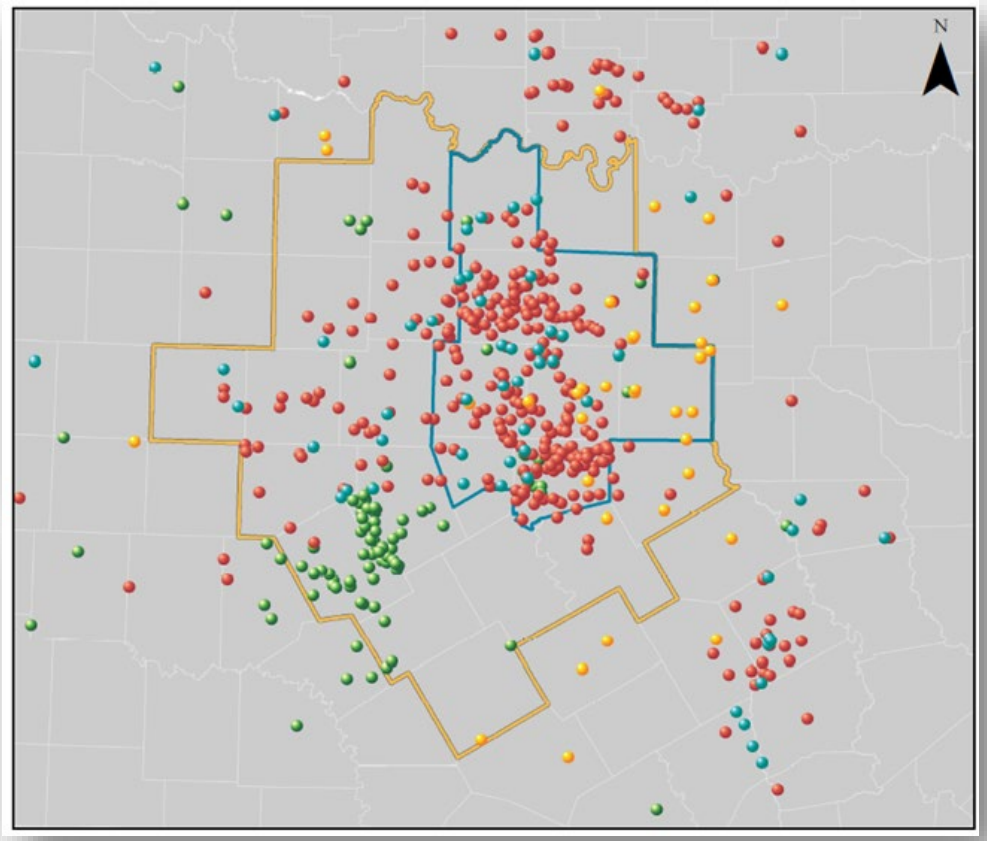
U.S. 2015 O&G CH_4 emissions are 60% higher than estimated by EPA GHGI.



Why does the traditional paradigm fail?

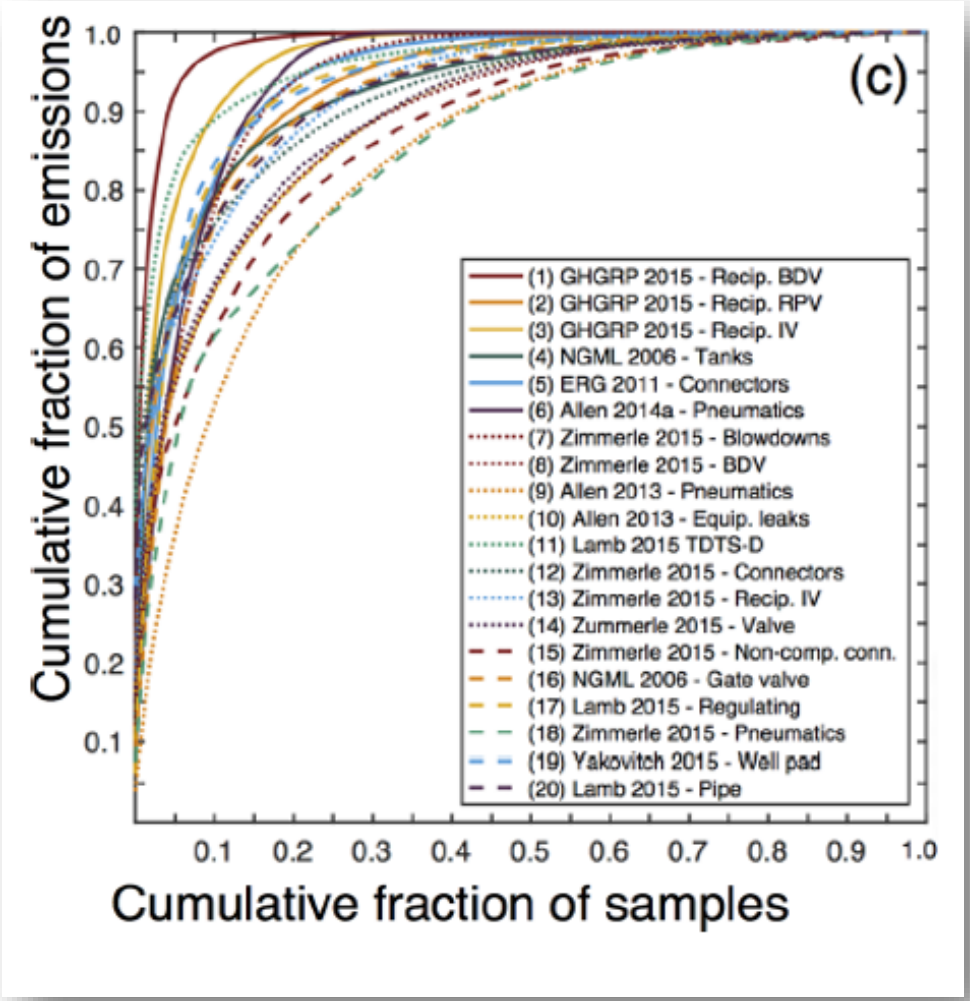
Activity data have high uncertainty.

Photos: Google Earth



https://pubs.acs.org/doi/abs/10.1021/es506359c

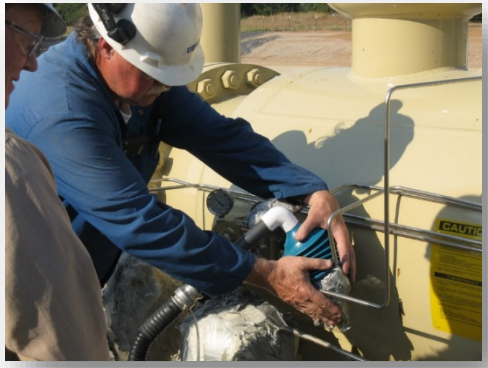
Skewed emission rate distributions lead to low biased emission factors.



https://pubs.acs.org/doi/abs/10.1021/acs.est.6b04303

Large emission sources are difficult to quantify at the component-level.

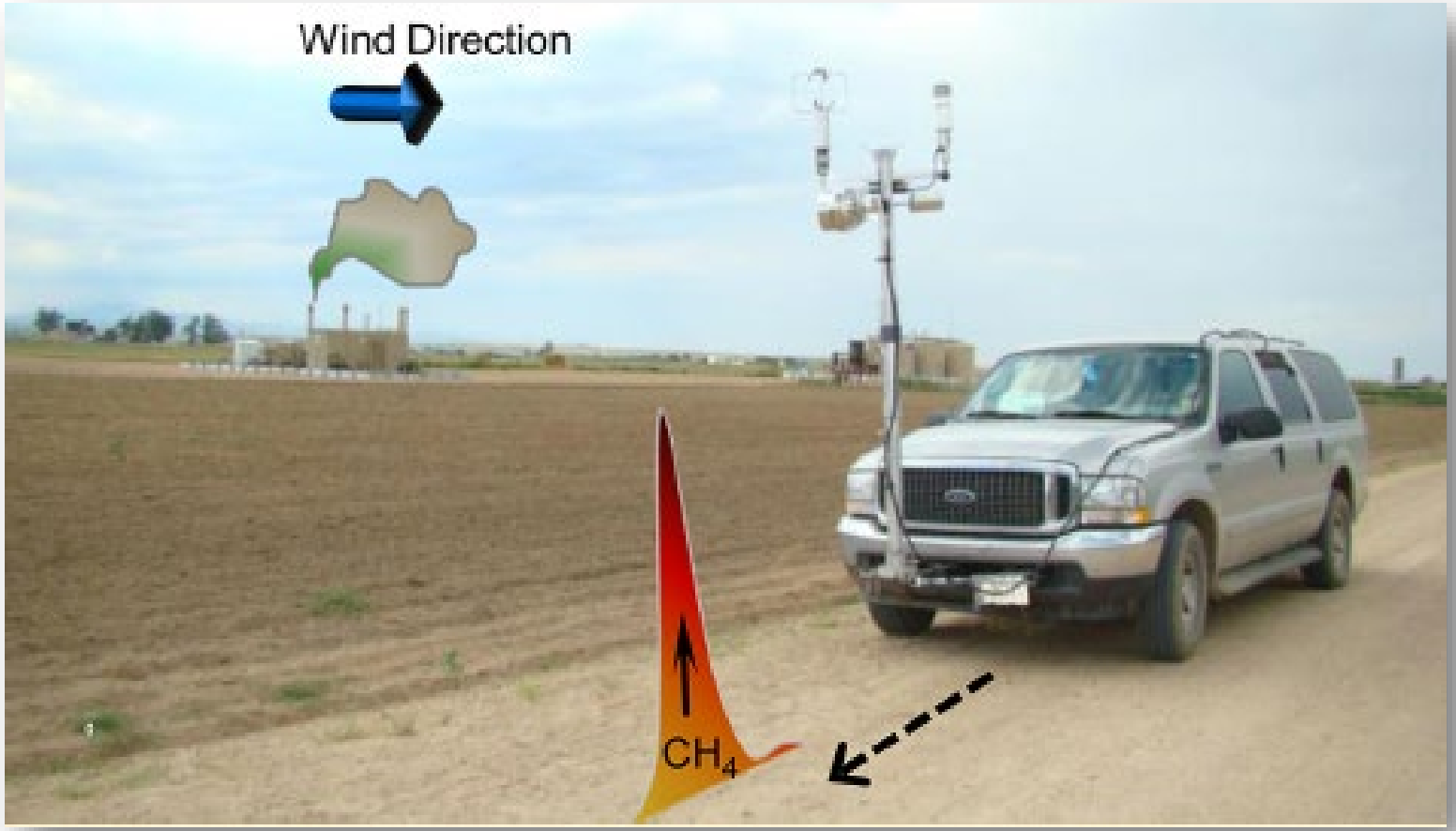
https://pubs.acs.org/doi/abs/10.1021/acs.est.6b00705



Photos: University of Texas

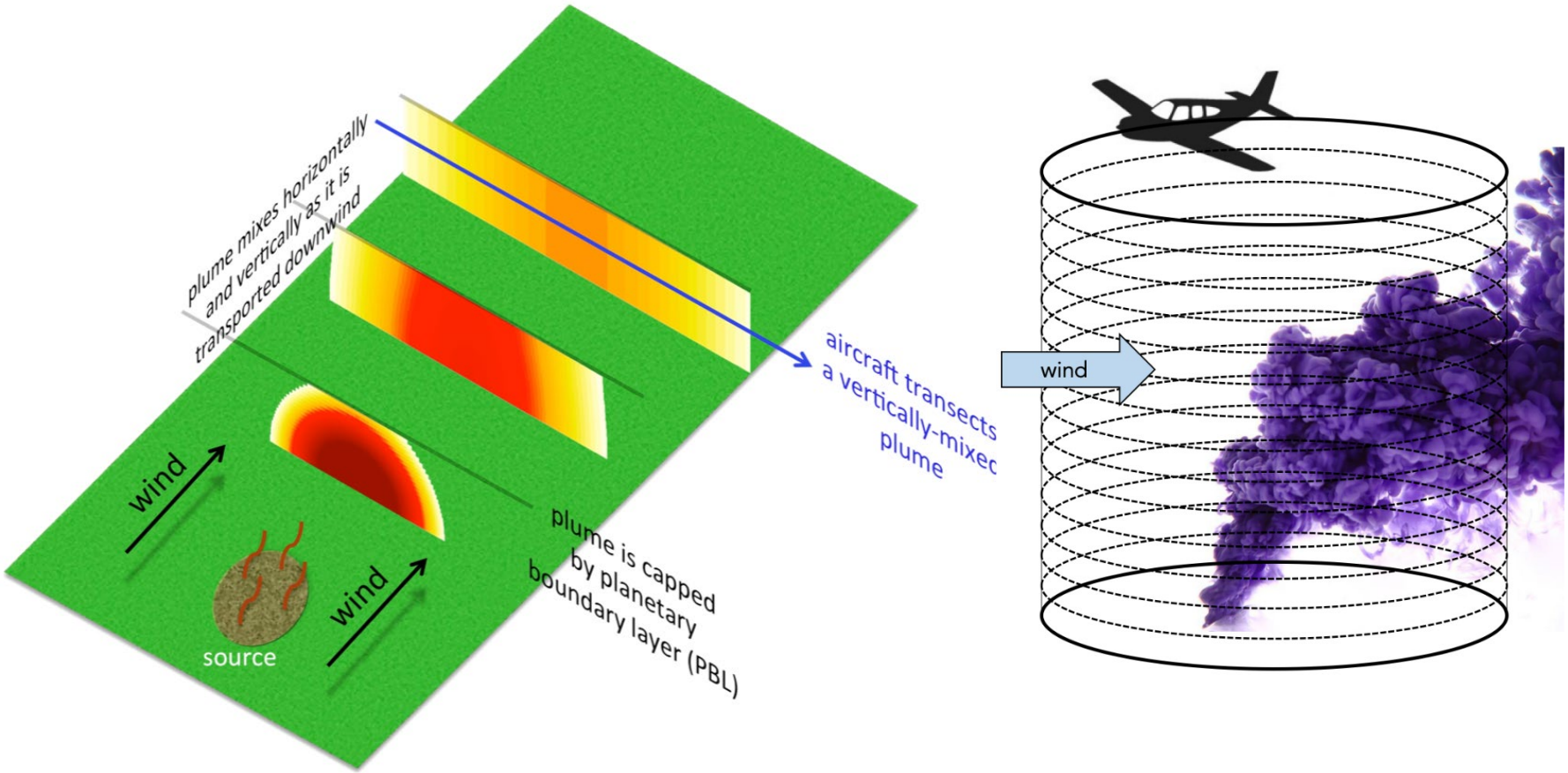
What are alternative approaches for quantifying emissions?

Ground-based, mobile approaches quantify site-level emissions by measuring downwind plumes.



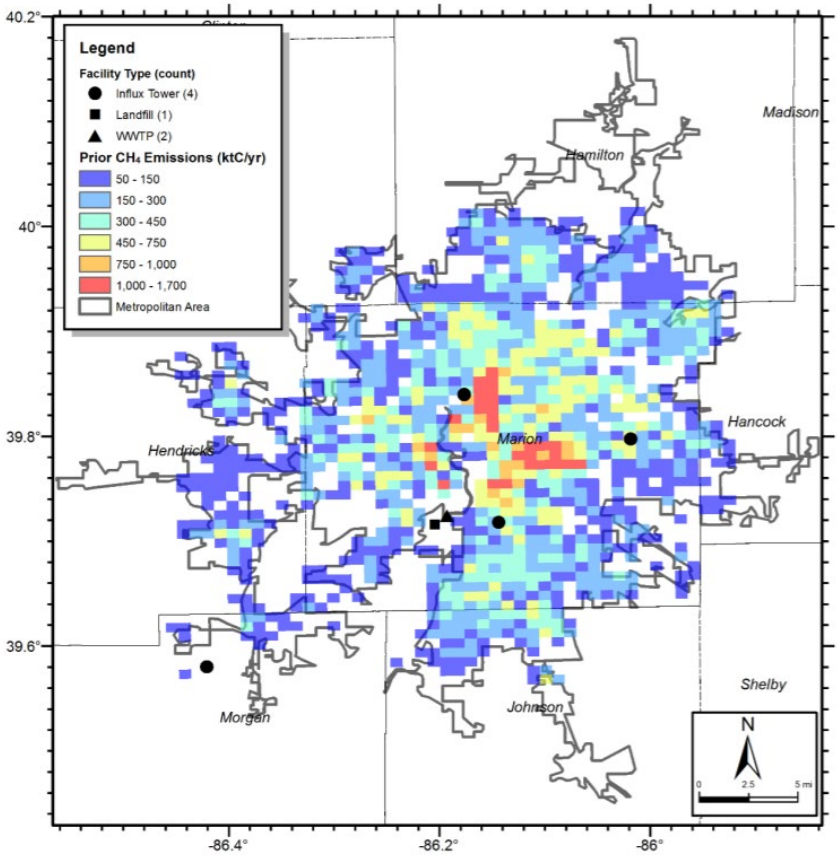
https://pubs.acs.org/doi/abs/10.1021/es503070q

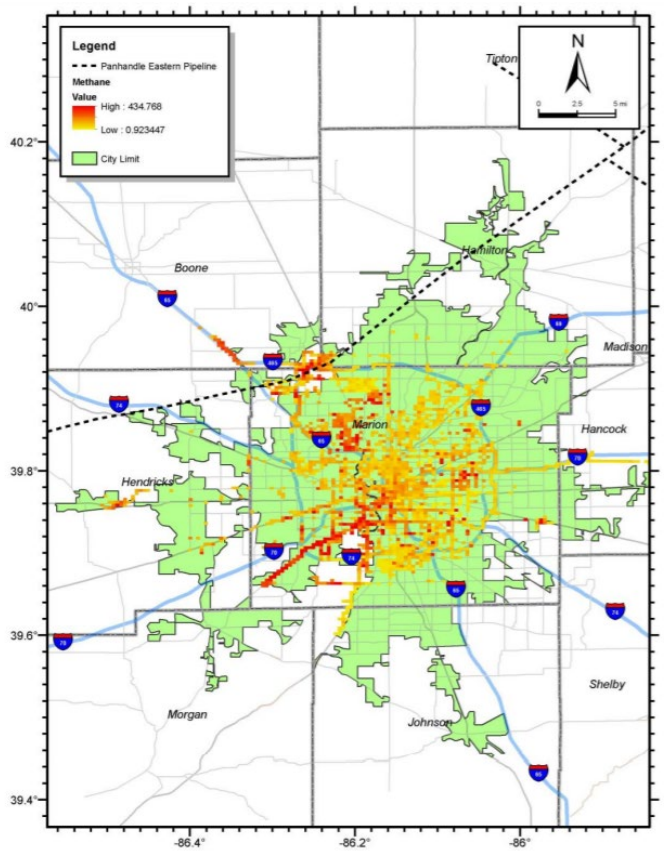
Aerial mass balance approaches quantify emissions by measuring upwind/downwind concentrations.



https://www.scientificaviation.com/methods/

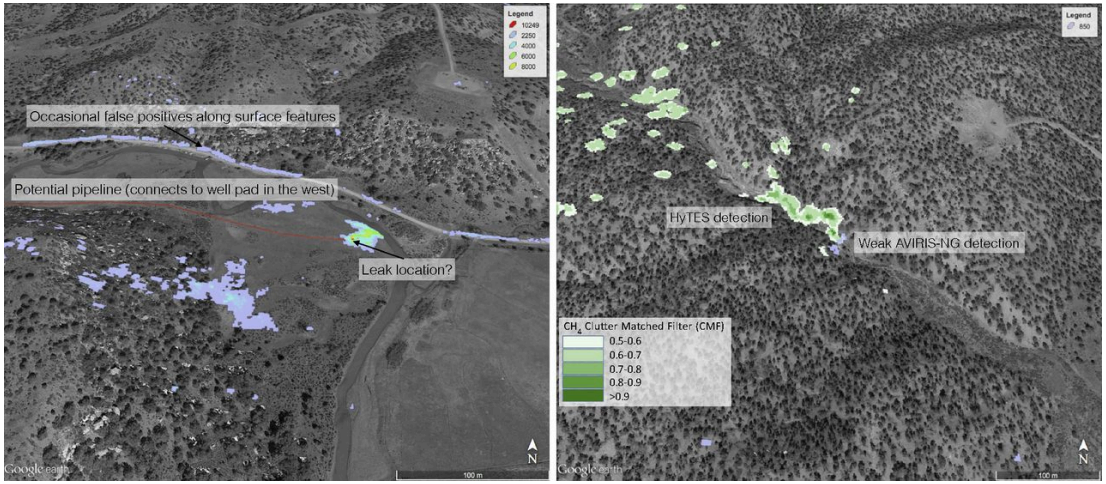
Inversion approaches use atmospheric transport models to solve for inventories that best fit observed concentration data.





https://pubs.acs.org/doi/abs/10.1021/acs.est.6b01198

Remote sensing approaches measure column-average concentrations to image plumes.



https://www.pnas.org/content/113/35/9734

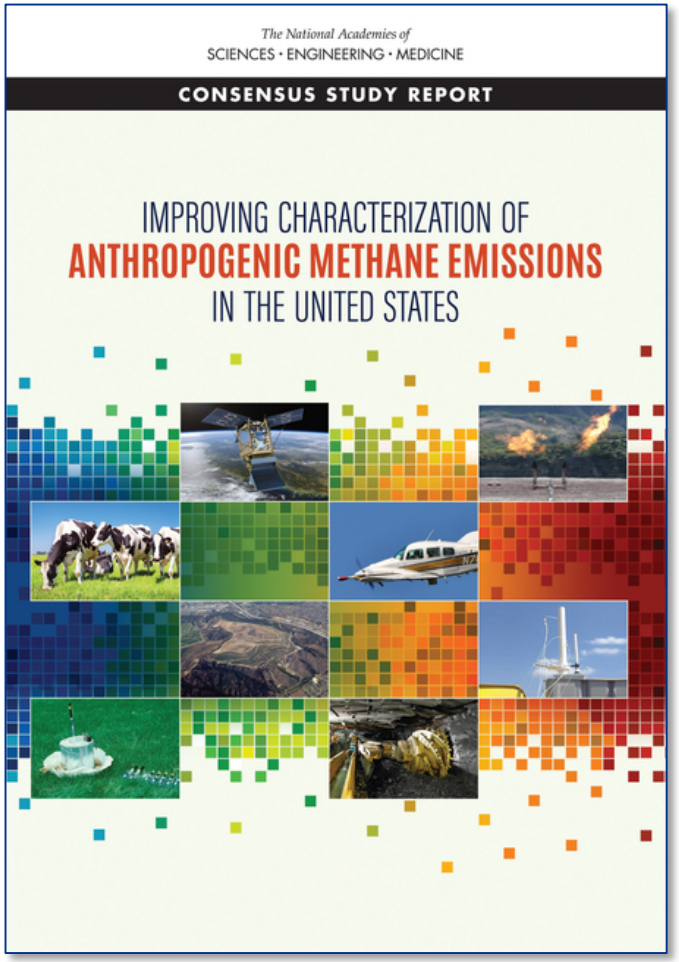
http://kairosaerospace.com/wp-content/uploads/2018/02/Kairos-Overview.pdf

MethaneSAT will monitor emissions globally.

https://www.edf.org/climate/space-technology-can-cut-climate-pollution-earth

What are key features of the new paradigm?

- Incorporates measurement data from multiple spatial scales
- Validates spatially explicit inventories with independent, empirical data
- Prioritizes accuracy of total emission estimates over source disaggregation
- Prioritizes continuous improvement and transparency over consistency
- Data can support performance-based emission reduction strategies



http://nas-sites.org/dels/studies/methane-study/

Ongoing work

- Innovative leak detection
  - https://www.edf.org/methane-detectors-challenge
  - https://methane.stanford.edu/
- Assessing equivalency
  - https://energy.colostate.edu/metec/
  - https://eao.stanford.edu/research-areas/FEAST
  - https://www.edf.org/sites/default/files/documents/EDFAlternativeCompliance Report_0.pdf
- Transparent reporting
  - https://www.edf.org/sites/default/files/documents/setting-the-bar.pdf
  - https://www.ccacoalition.org/en/resources/oil-gas-methane-partnership-ogmp-overview