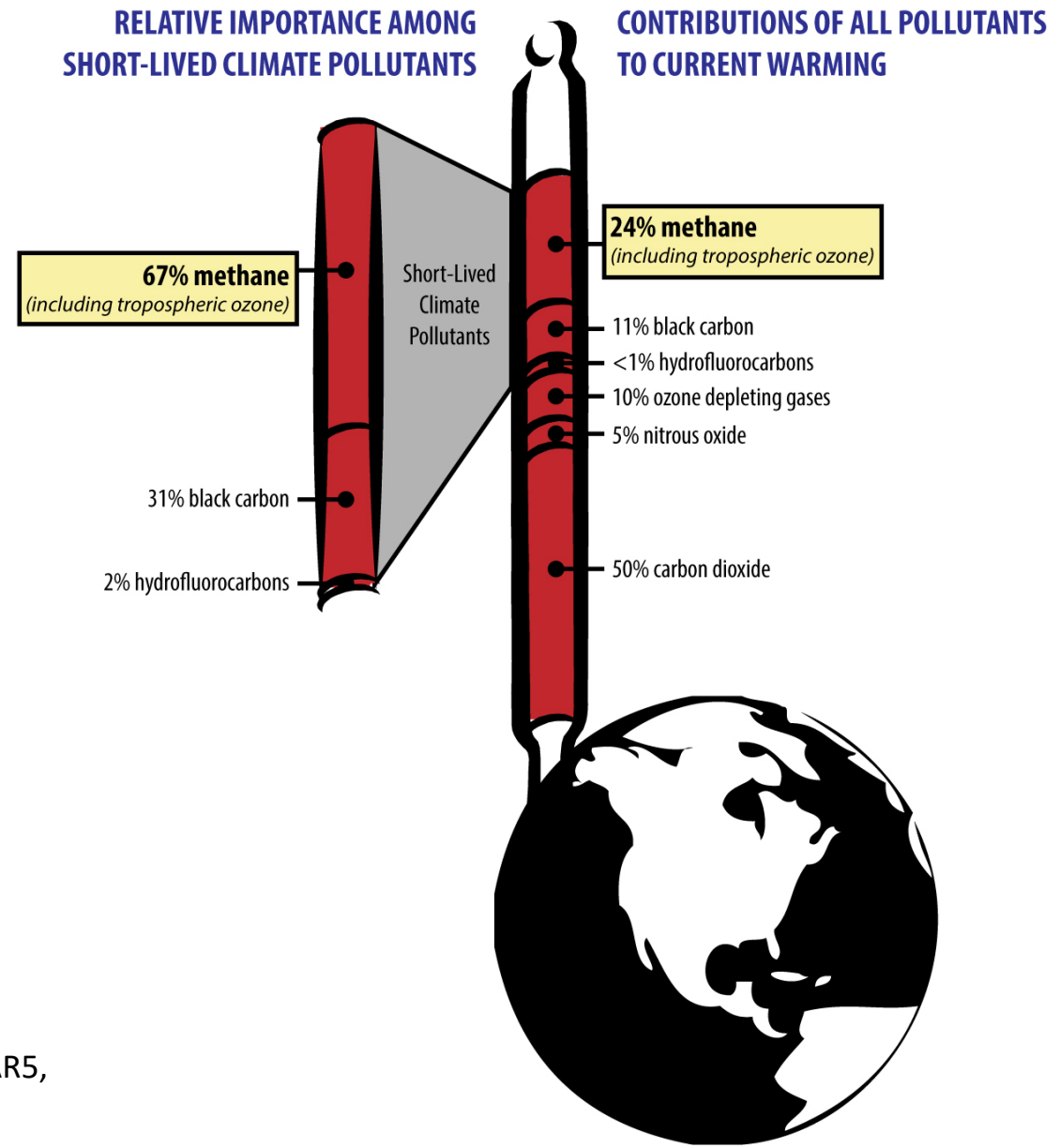
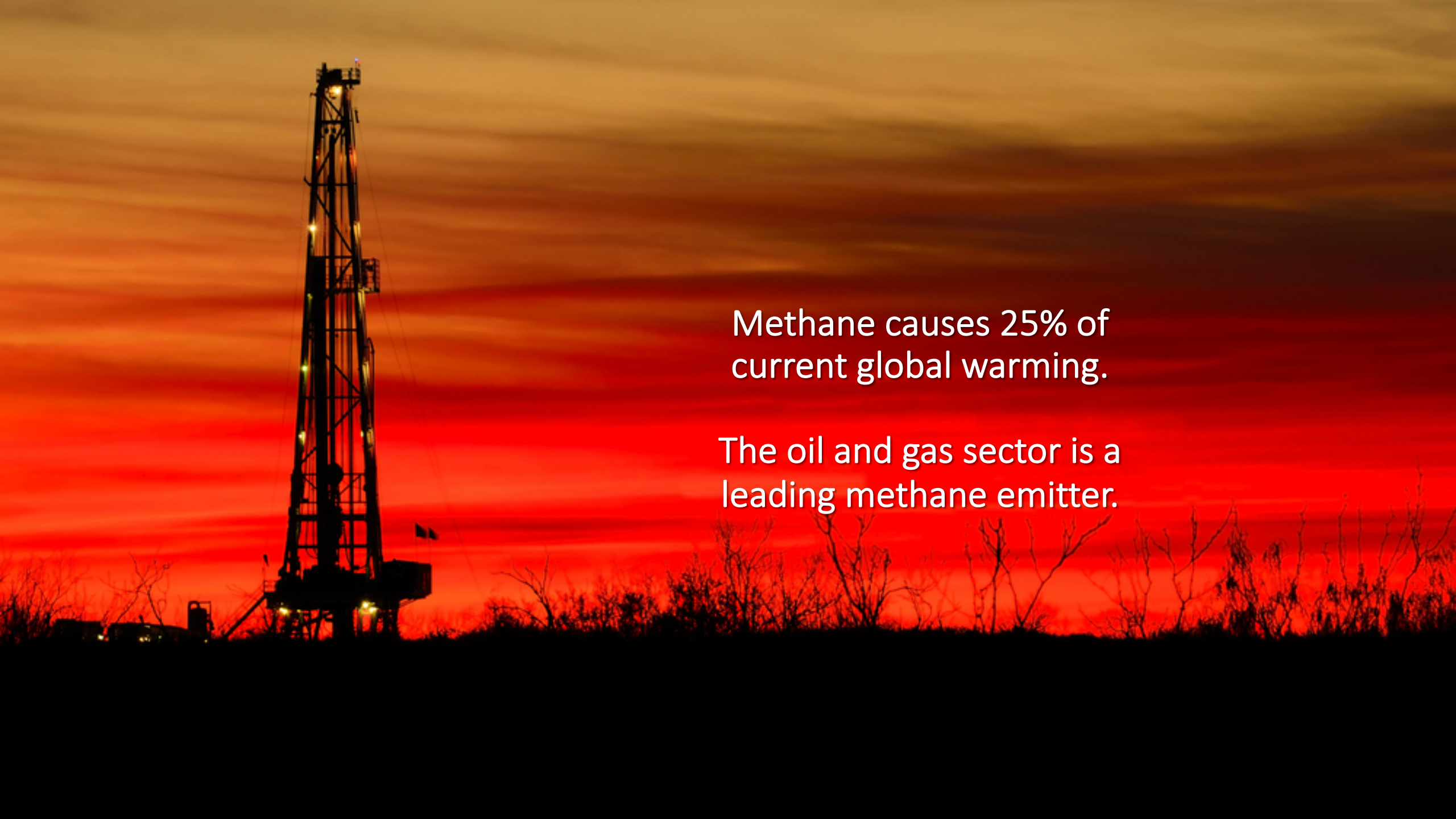
Methane Emissions from the Oil and Gas Supply Chain

Steven Hamburg
Chief Scientist
Environmental Defense Fund

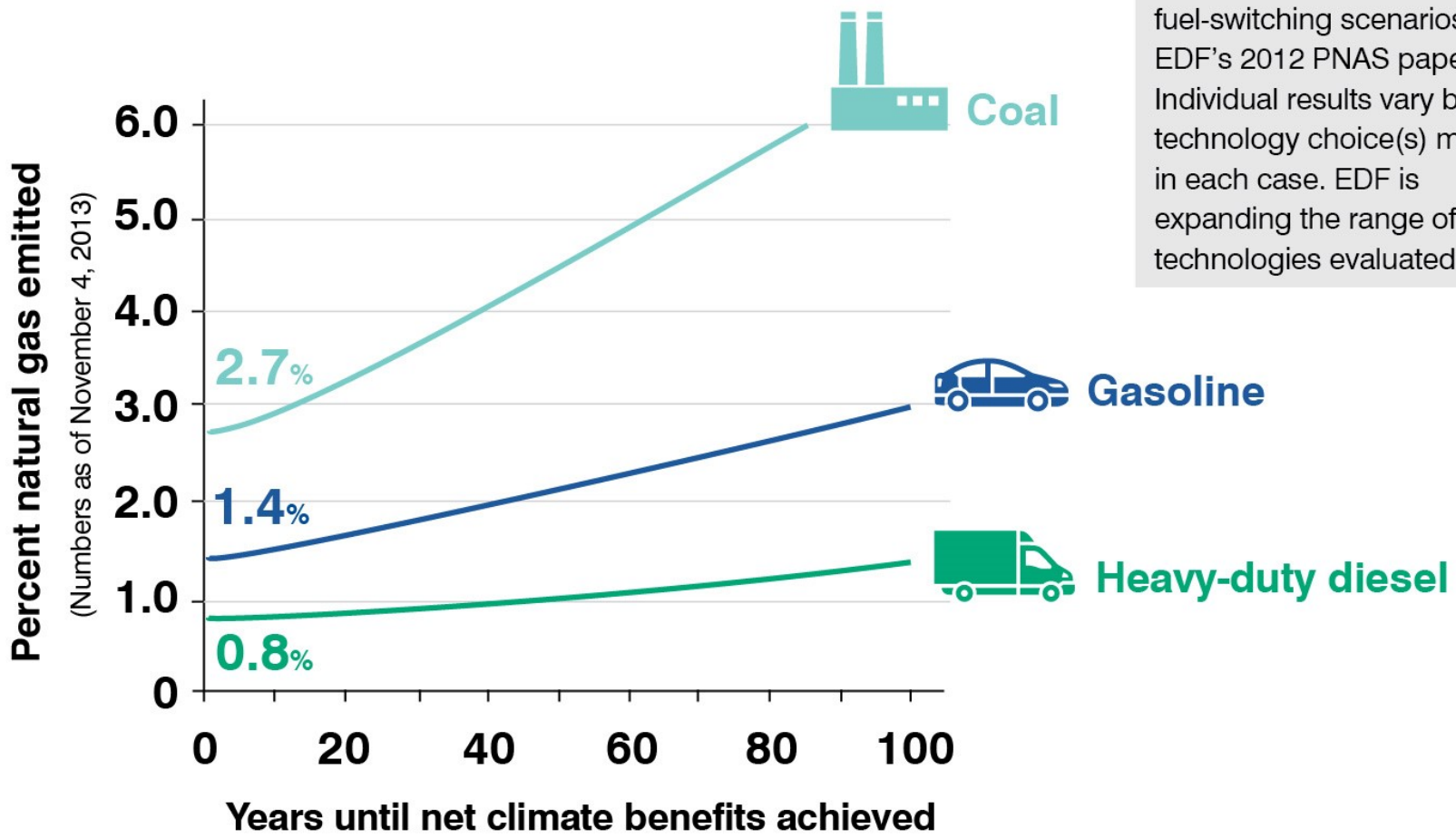
CH_4 causes ~25% of today's radiative forcing



Adapted from IPCC AR5, Table 8.SM.6


Methane causes 25% of
current global warming.
The oil and gas sector is a
leading methane emitter.

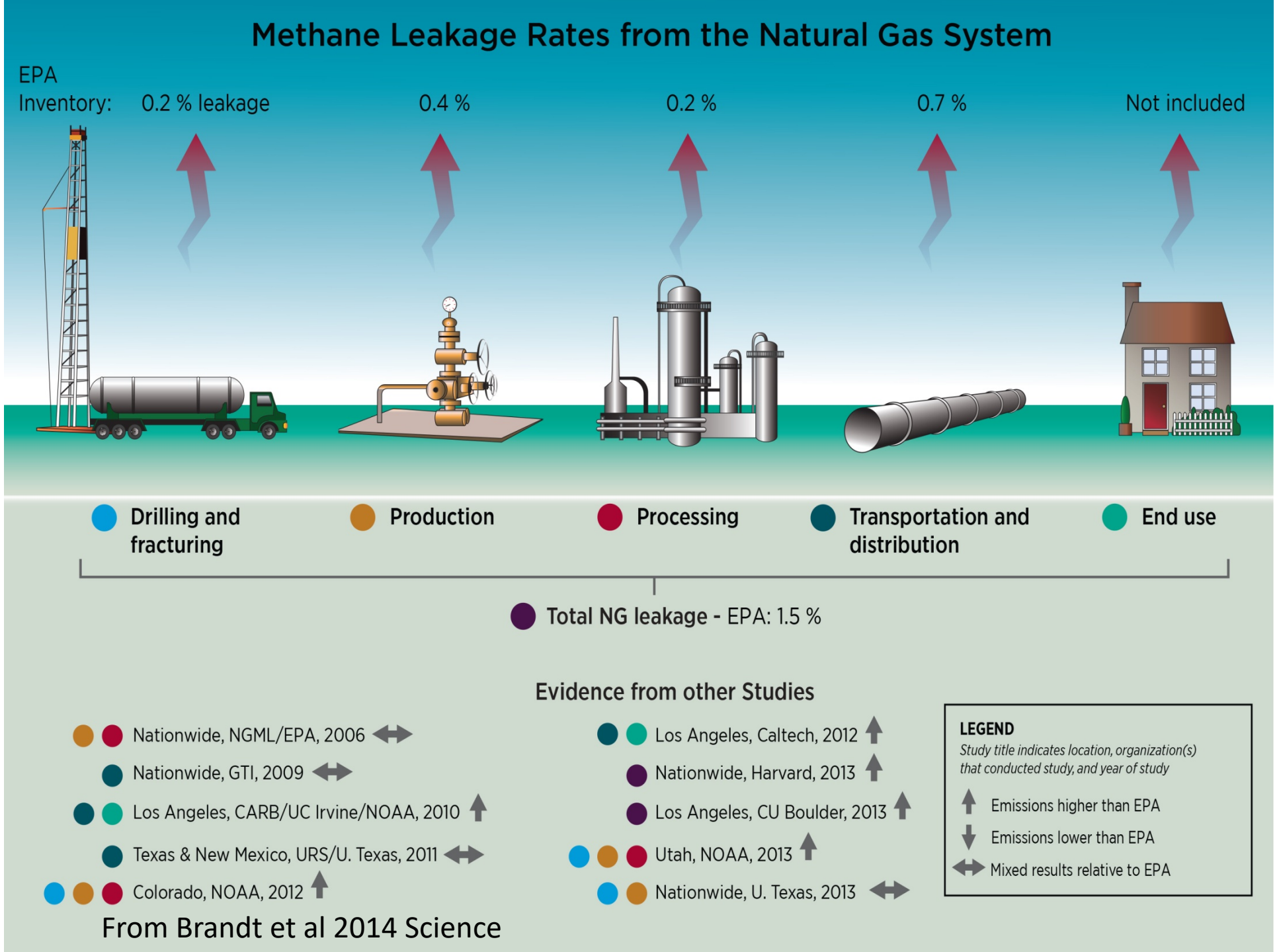
Can Natural Gas Deliver Sustained Climate Benefits?



Updated calculations of fuel-switching scenarios in EDF's 2012 PNAS paper.* Individual results vary by the technology choice(s) made in each case. EDF is expanding the range of technologies evaluated.

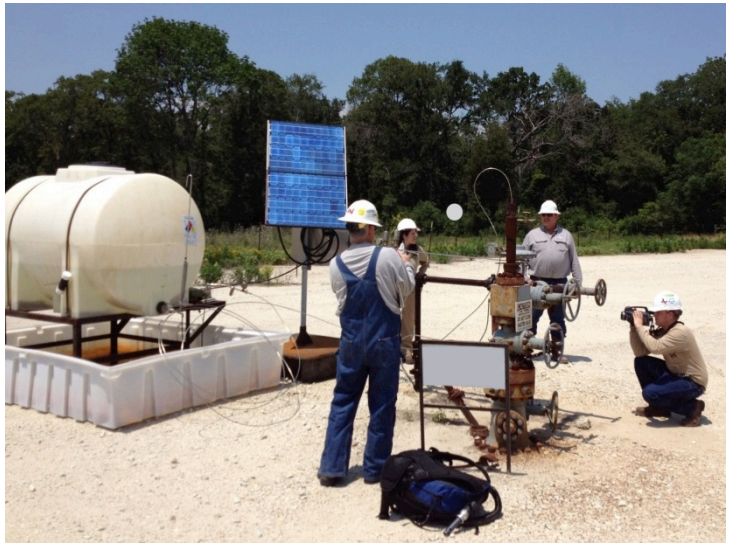
EDF
ENVIRONMENTAL DEFENSE FUND*
Finding the ways that work

Adapted from Alvarez et al. (2012) PNAS, **109: 6435–6440, reflecting new IPCC AR5 & 2013 EPA GHG data. IPCC updates: (1) direct/indirect radiative forcing of CH_4 and CO_2, (2) CH_4 lifetime, (3) CO_2 impulse response function. Additional effects due to climate-carbon feedbacks and CO_2 from the oxidation of CH_4 not included (AR5 lacks data to support time-dependent analysis but EDF believes these effects to be small). Emissions updates include factors in Table 1 and corresponding L_{REF} values in Table S1 of PNAS paper; an L_{REF} value specific to heavy-duty CNG vehicles is now used.*



From Brandt et al 2014 Science

Catalyzing Science

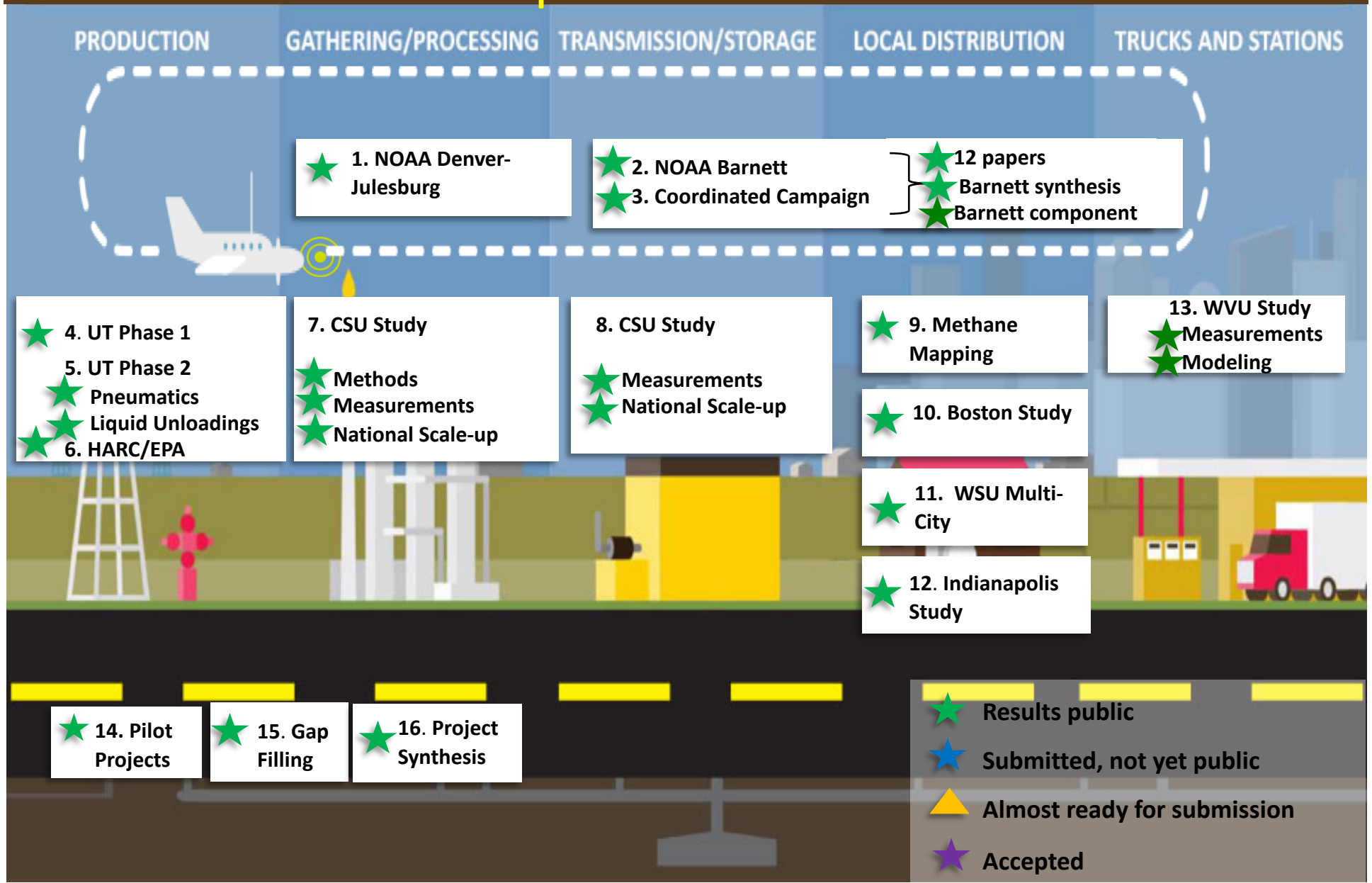


Read more:
edf.org/climate/methanestudies

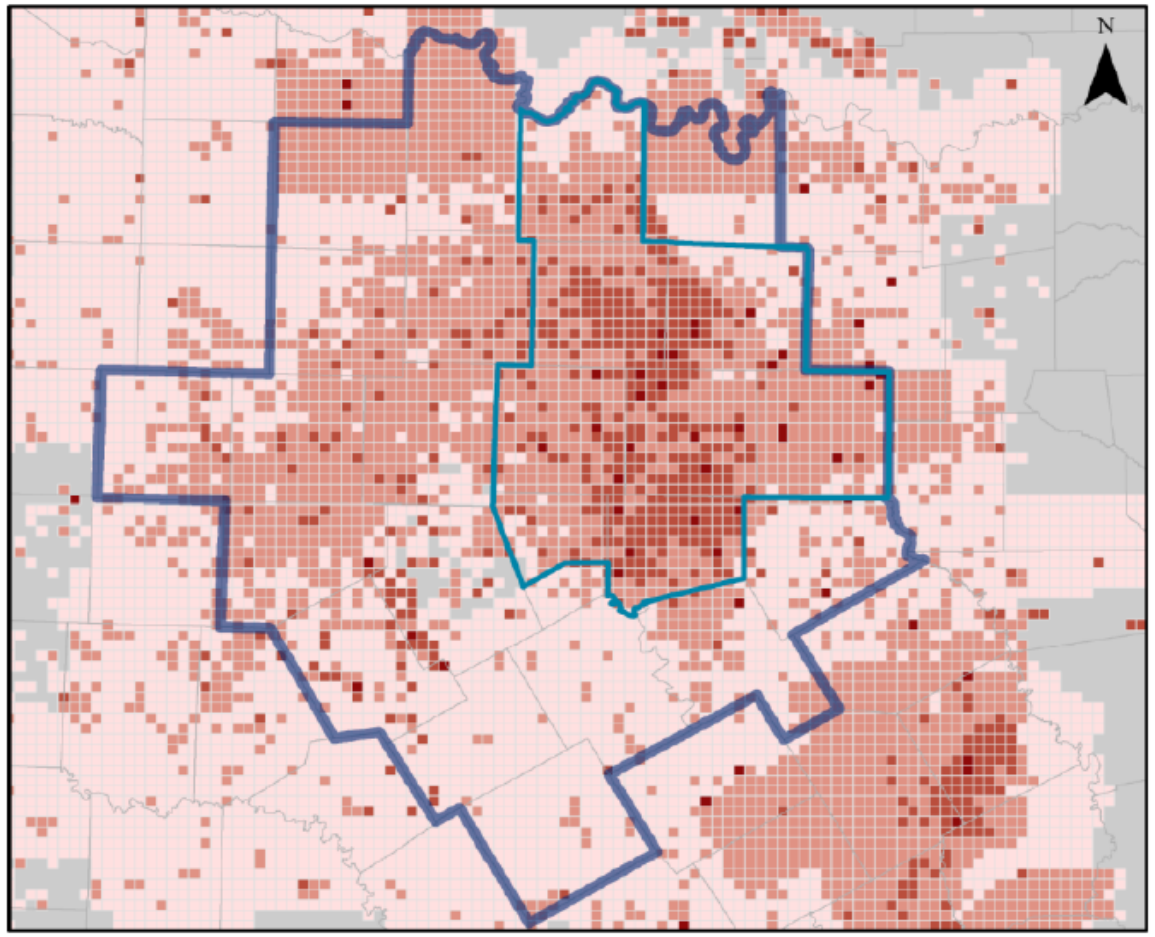
5 principles:

- Led by *academic scientis*ts
- Employ *multiple methodologies* whenever possible
- Seek review by *independent* scientific experts
- Make all data *public* to ensure *transparency*
- Publish results in a *peer reviewed science journal*

EDF STUDIES BY SUPPLY CHAIN SEGMENT: September 2017

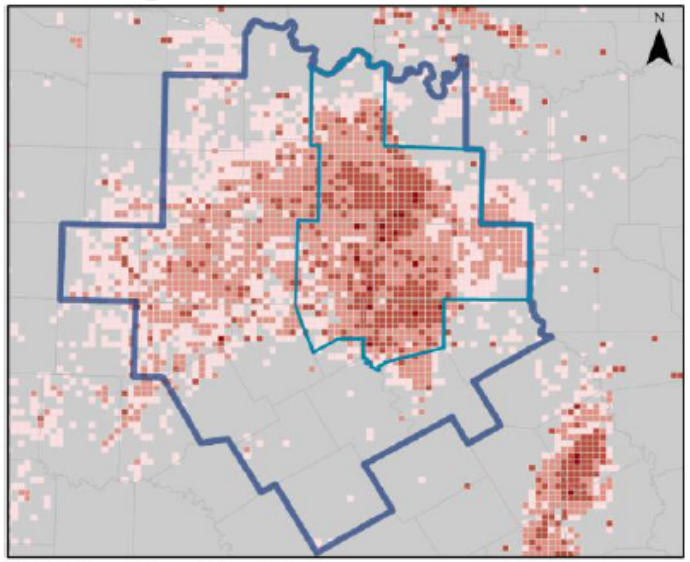


Total Methane Emissions



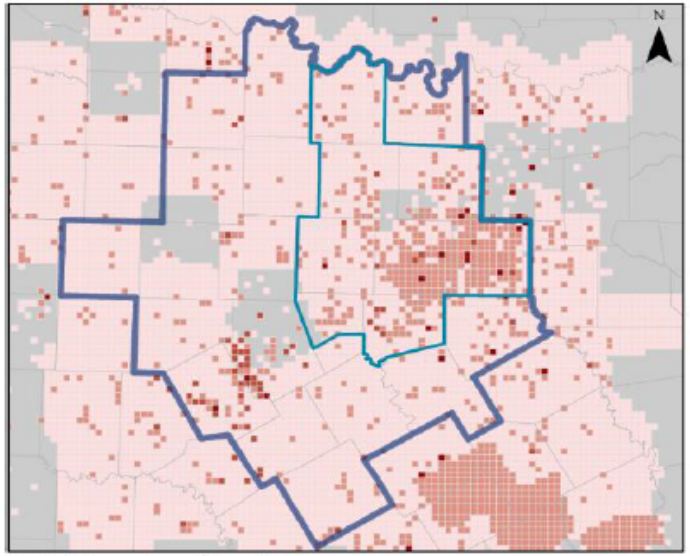
0 20 40 80 120 160
Kilometers

Thermogenic Methane Emissions



0 20 40 80 120 160
Kilometers

Biogenic Methane Emissions



0 20 40 80 120 160
Kilometers

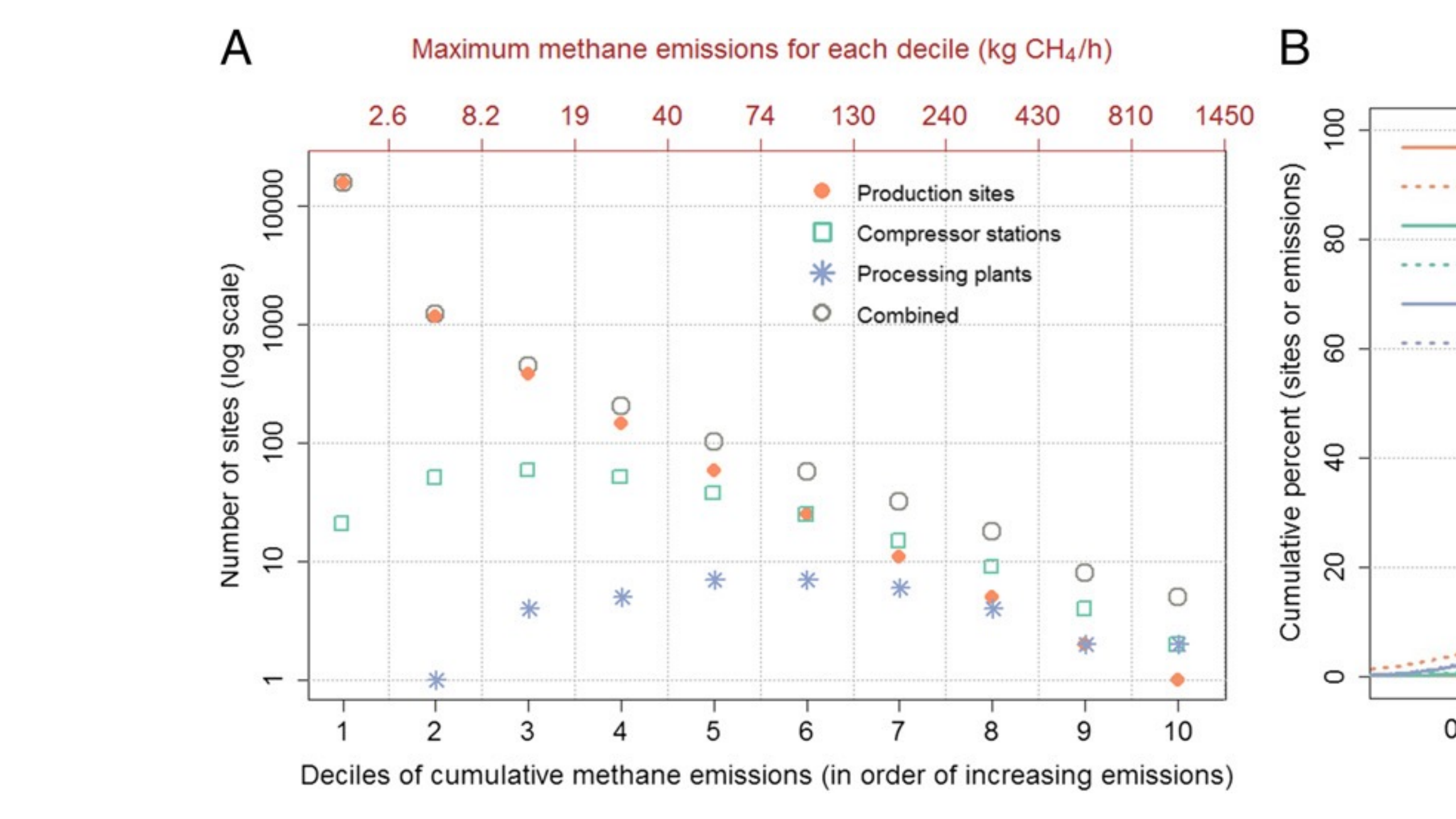
Methane Emissions (kg/h)

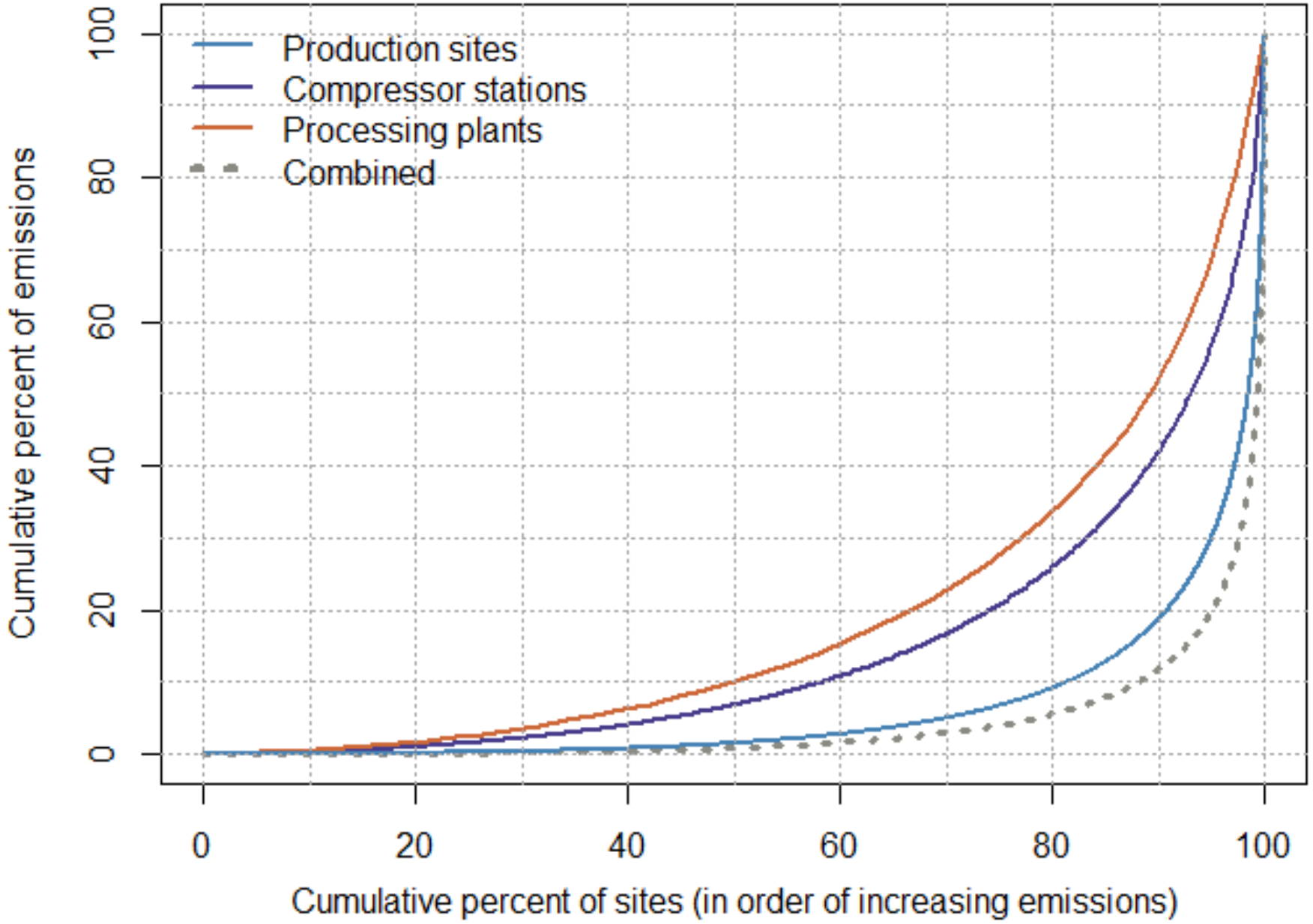
- 1 - 3.4
- 3.4 - 26.0
- 26.0 - 222
- > 222

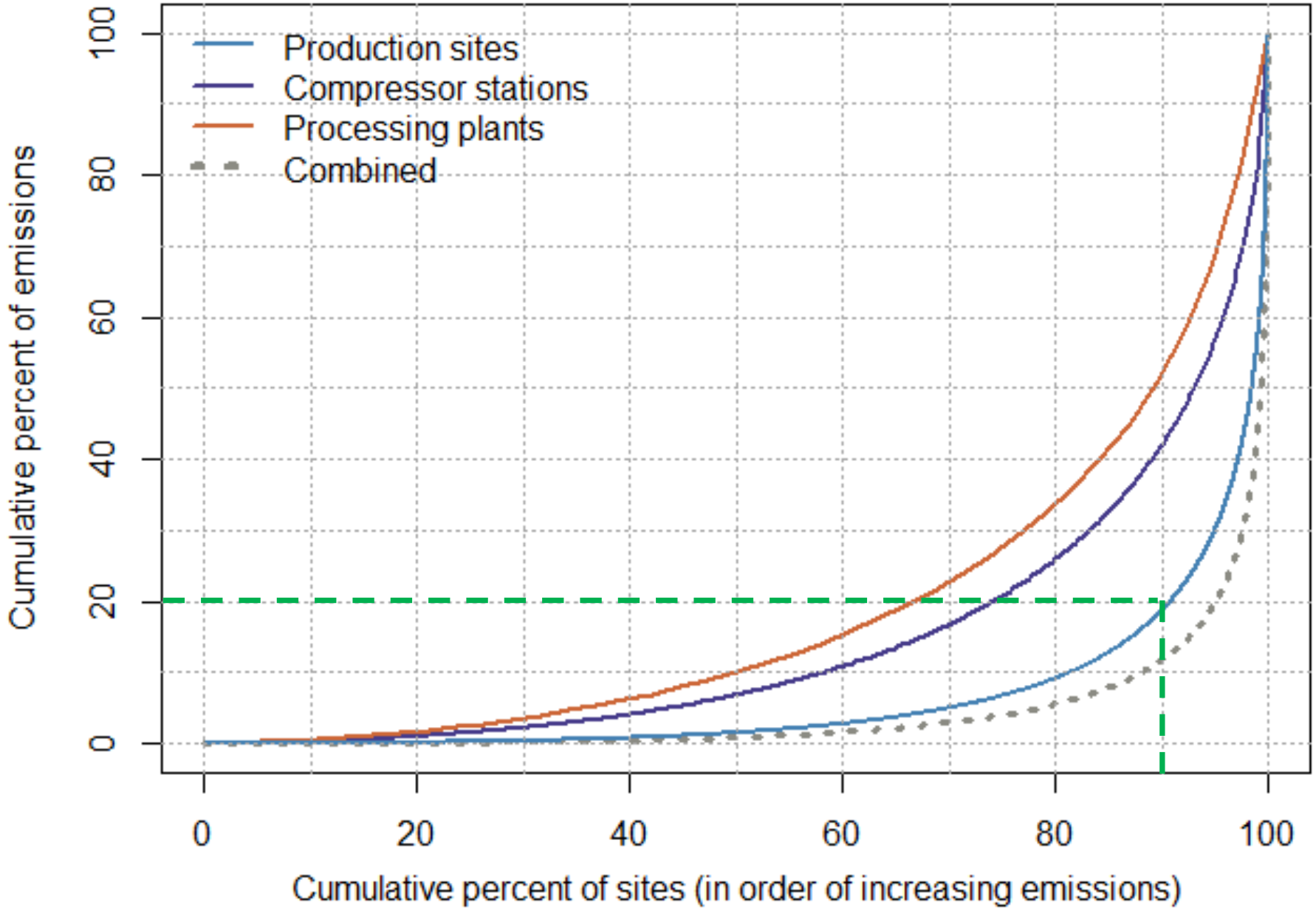
Barnett Shale core counties

RRC Barnett Shale Boundary

Lyon et al.


A
Maximum methane emissions for each decile (kg CH4/h)
2.6
8.2
19
40
74
130
240
430
810
1450
Number of sites (log scale)
10000
1000
100
10
1
Production sites
Compressor stations
Processing plants
Combined
1
2
3
4
5
6
7
8
9
10
Deciles of cumulative methane emissions (in order of increasing emissions)
B
Cumulative percent (sites or emissions)
100
80
60
40
20
0


Production sites
Compressor stations
Processing plants
Combined
Cumulative percent of emissions
0
20
40
60
80
100
Cumulative percent of sites (in order of increasing emissions)


Production sites
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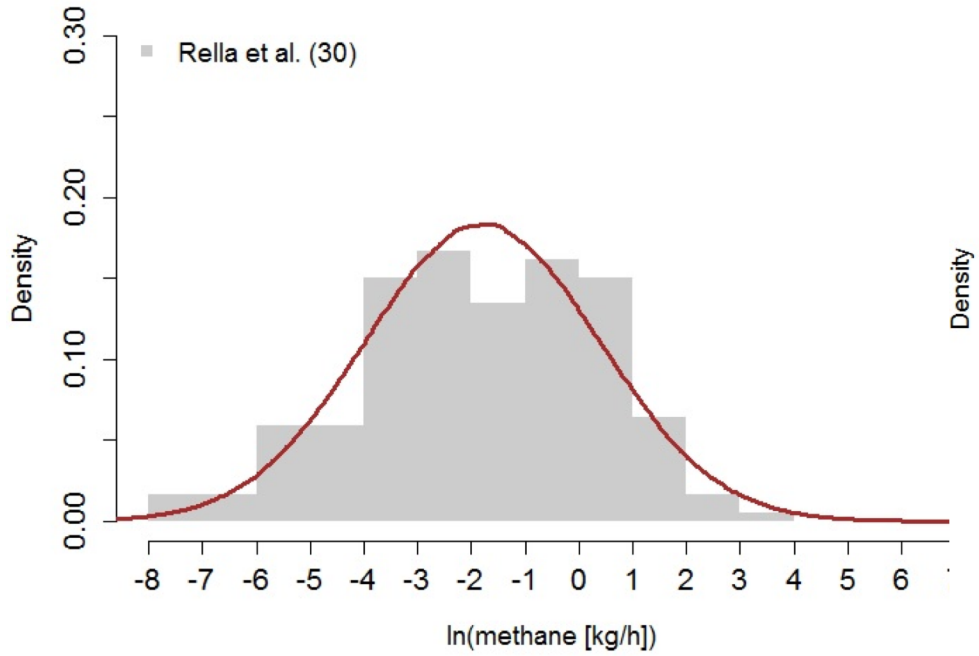
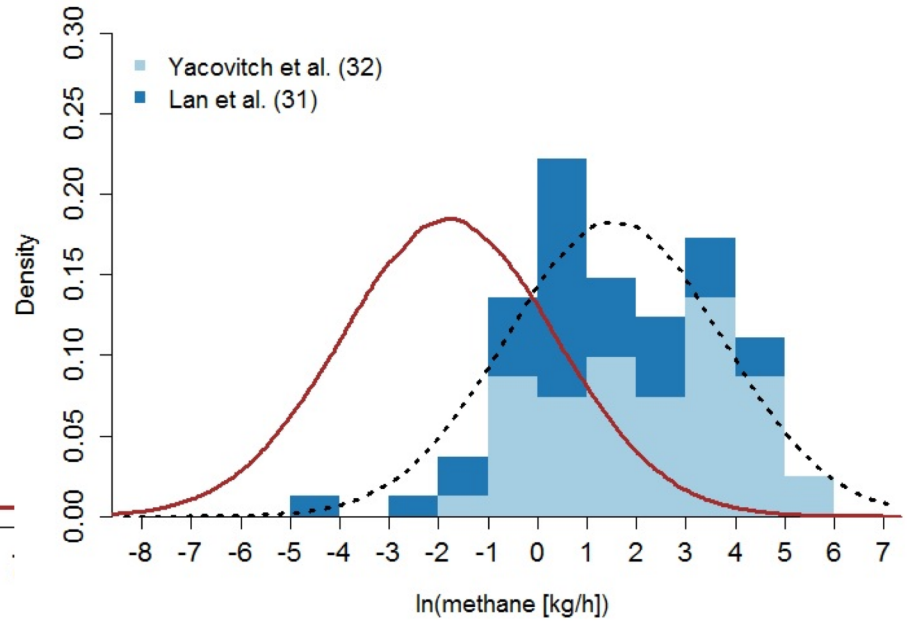
Combined
Cumulative percent of emissions
0
20
40
60
80
100
Cumulative percent of sites (in order of increasing emissions)
0
20
40
60
80
100

Integrating Datasets – understanding the fat tail





Different Methodologies

Most "Top Down" studies reveal higher emissions than "Bottom Up" methods.

Top Down

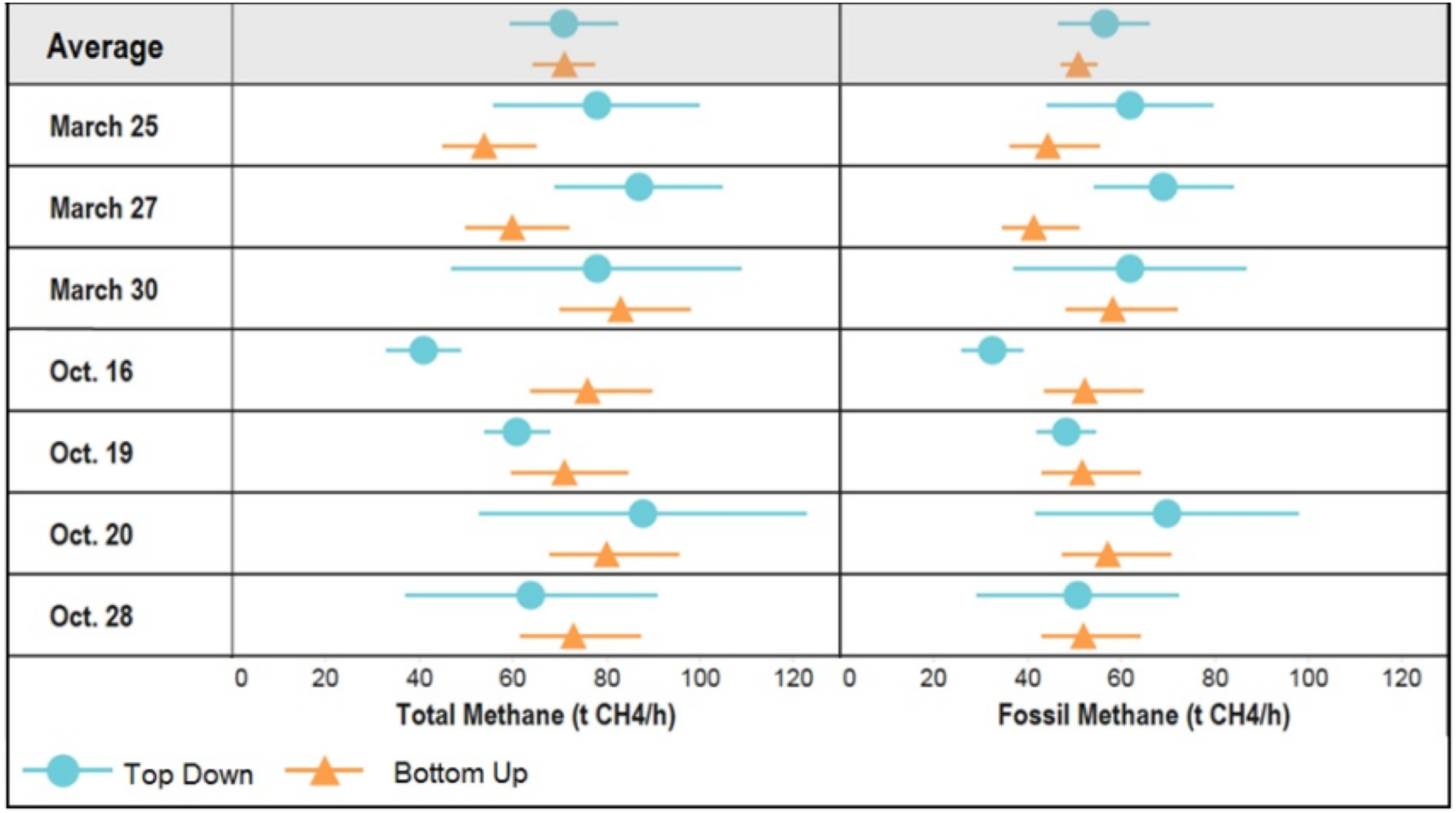
- Large scale-regional or national estimates
- Mass balance
- Atmospheric transport models
- Enhancement ratios (e.g., CH4/CO2)
- Attribution to oil & gas required

Bottom Up

- Component- or activity-based
- Facility-level (0.05 to 5 km downwind)
- Combine emissions and activity factors

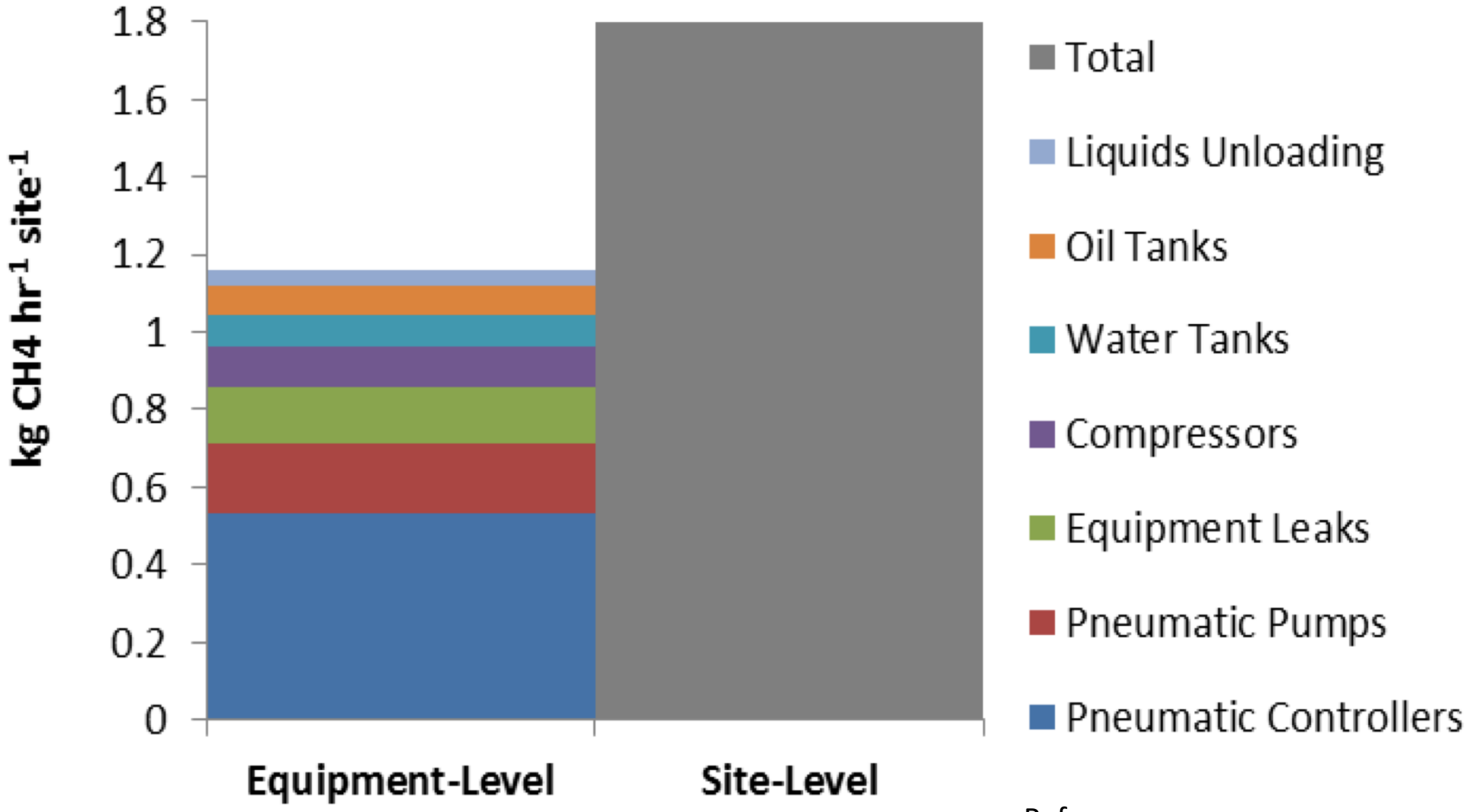
Barnett: Top-Down and Bottom-Up agree

Mean Relative Difference: 0.1% ± 21% (total) and 10% ± 32% (fossil)



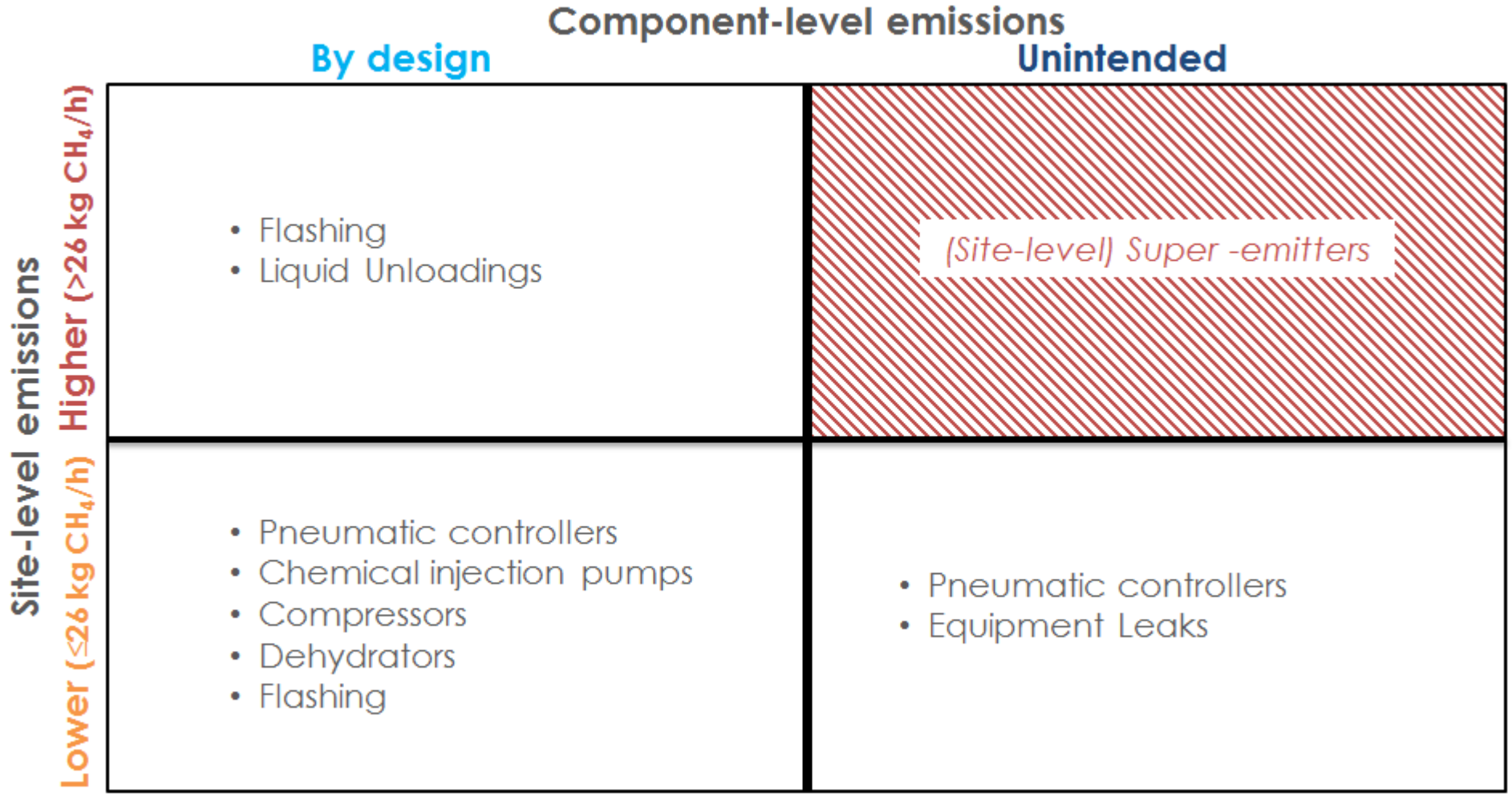
Zavala-Araiza et al. 2015 (PNAS)

A closer look at Barnett Shale well pads



References:
http://www.pnas.org/content/112/51/15597.short
https://www.nature.com/articles/ncomms14012

Tank flashing and liquids unloading explain the magnitude but not the prevalence of high-emitting well pads



Zavala-Araiza D, et al. Nature Communications 2017.


Google maps
Street View
google.com/streetview

Climate and energy

- The problem
- Cleaner, smarter energy
- Stronger laws and policies
- Private-sector partnerships
  - EDF Climate Corps
  - Work with labor unions
  - Maps of natural gas leaks
    - Why leaks are a problem
    - How to fix the problem
    - City snapshots
    - How this data is different
    - About the partnership
- Global initiatives
- Policy and resources
- Our experts

Oceans

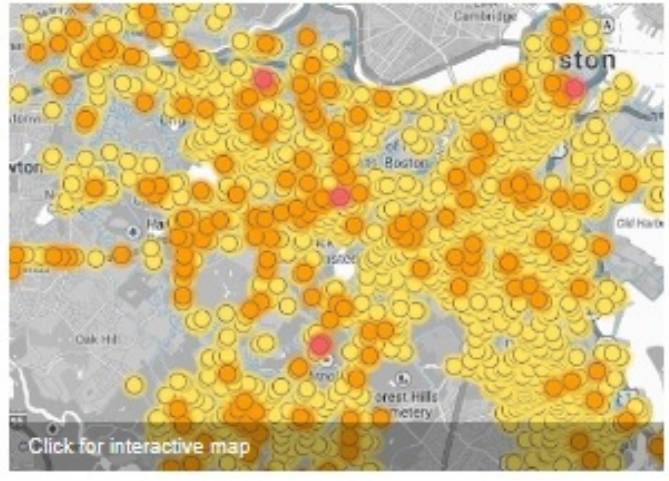
Ecosystems

Natural gas: Local leaks impact global climate

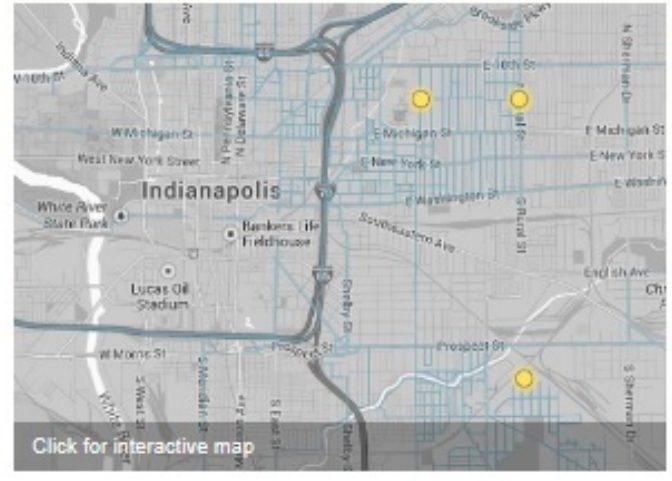
EDF and Google Earth Outreach use new approach to pinpoint climate pollution

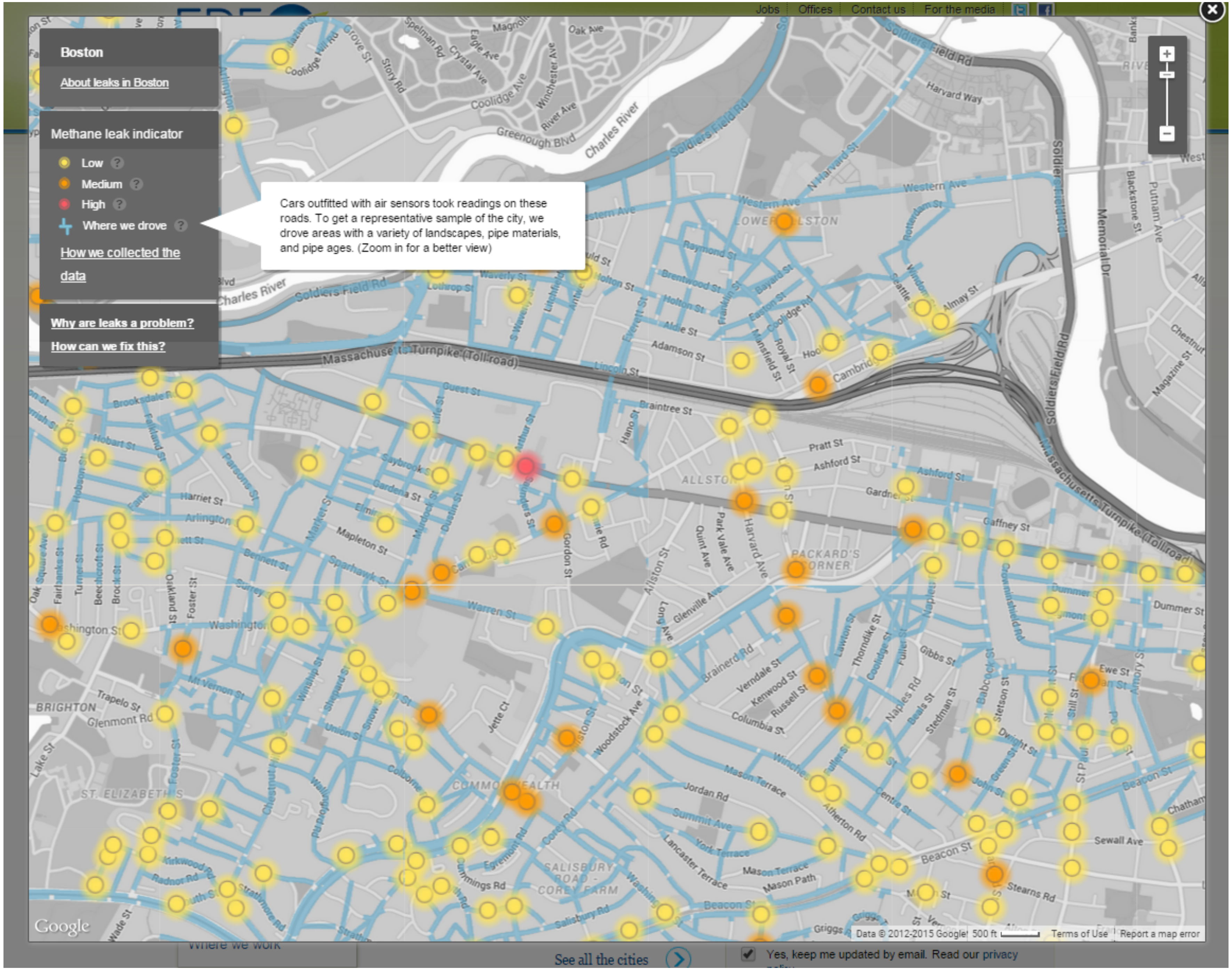
Natural gas heats our homes and cooks our dinner. But when natural gas—mostly methane—leaks into the air, it's a big problem for the climate. So EDF and Google Earth Outreach teamed up to build a faster, cheaper way to find and assess leaks under our streets and sidewalks. We tested it as part of a pilot mapping program, and here's what we found.

Boston: Older pipes, more leaks

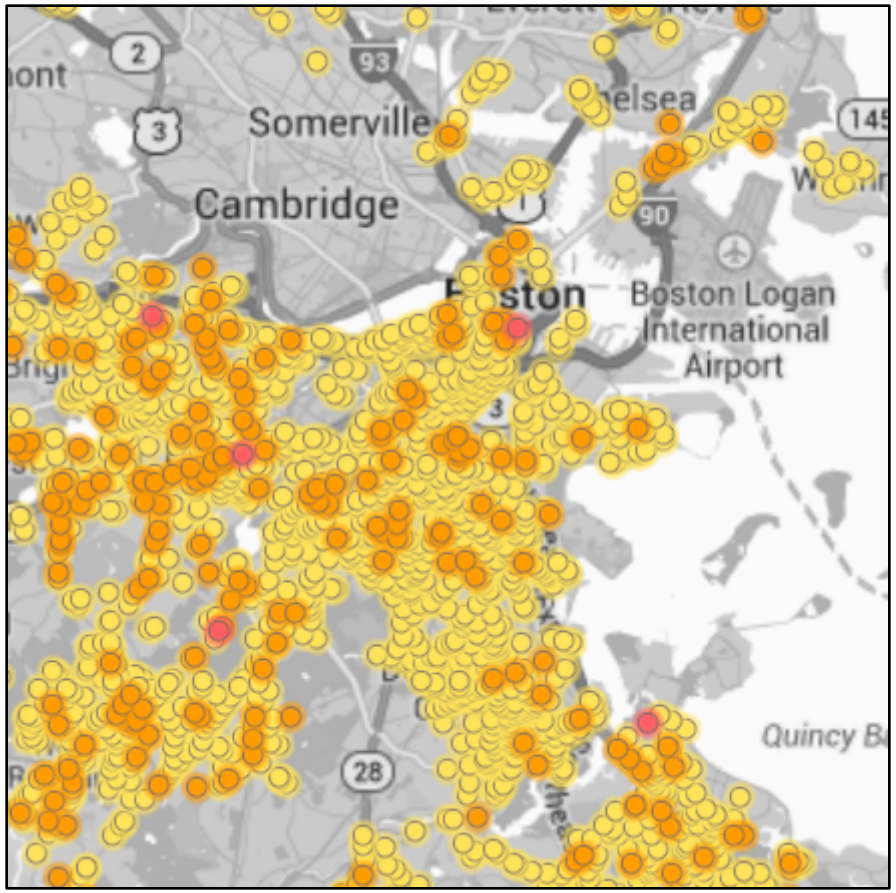


Indianapolis: Newer pipes, fewer leaks




Jobs
Offices
Contact us
For the media
Boston
About leaks in Boston
Methane leak indicator
Low
Medium
High
Where we drove
How we collected the data
Why are leaks a problem?
How can we fix this?
Cars outfitted with air sensors took readings on these roads. To get a representative sample of the city, we drove areas with a variety of landscapes, pipe materials, and pipe ages. (Zoom in for a better view)
Massachusetts Turnpike (Toll road)
Charles River
ALLSTON
LOWER ALLSTON
BRIGHTON
PACKARD'S CORNER
COMMONWEALTH
ST. ELIZABETH'S
SALISBURY ROAD - COREY FARM
Google
Data © 2012-2015 Google
500 ft
Terms of Use
Report a map error
See all the cities
Yes, keep me updated by email. Read our privacy

Boston vs. Indianapolis



City	Miles driven/ leak found
Boston, MA	1
Indianapolis, IN	200

EDF Coordinated Methane Synthesis

- Quantify methane emissions from the U.S. oil and gas supply chain (well to meter)
- Synthesizes recently published datasets
  - includes site-level measurements of >400 well pads across 6 U.S. basins
- Compares site-level estimates with aerial surveys of 9 basins
- 24 co-authors from 16 research organizations

Synthesis Collaborators

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Paul B. Shepson

Stanford University
Adam R. Brandt

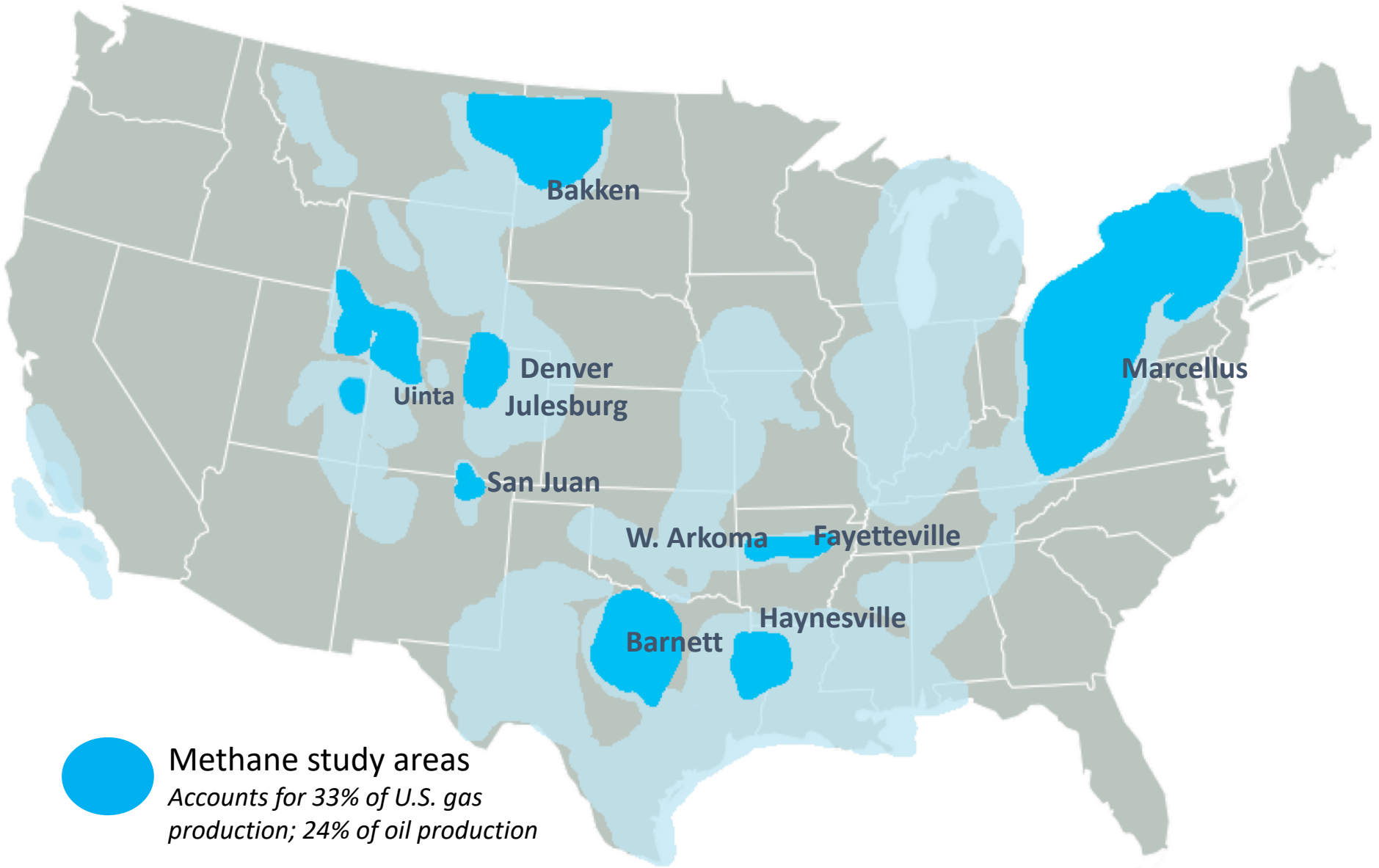
University of Cincinnati
Amy Townsend-Small

University of Michigan
Eric A. Kort

University of Texas
David T. Allen

Washington State University
Brian K. Lamb

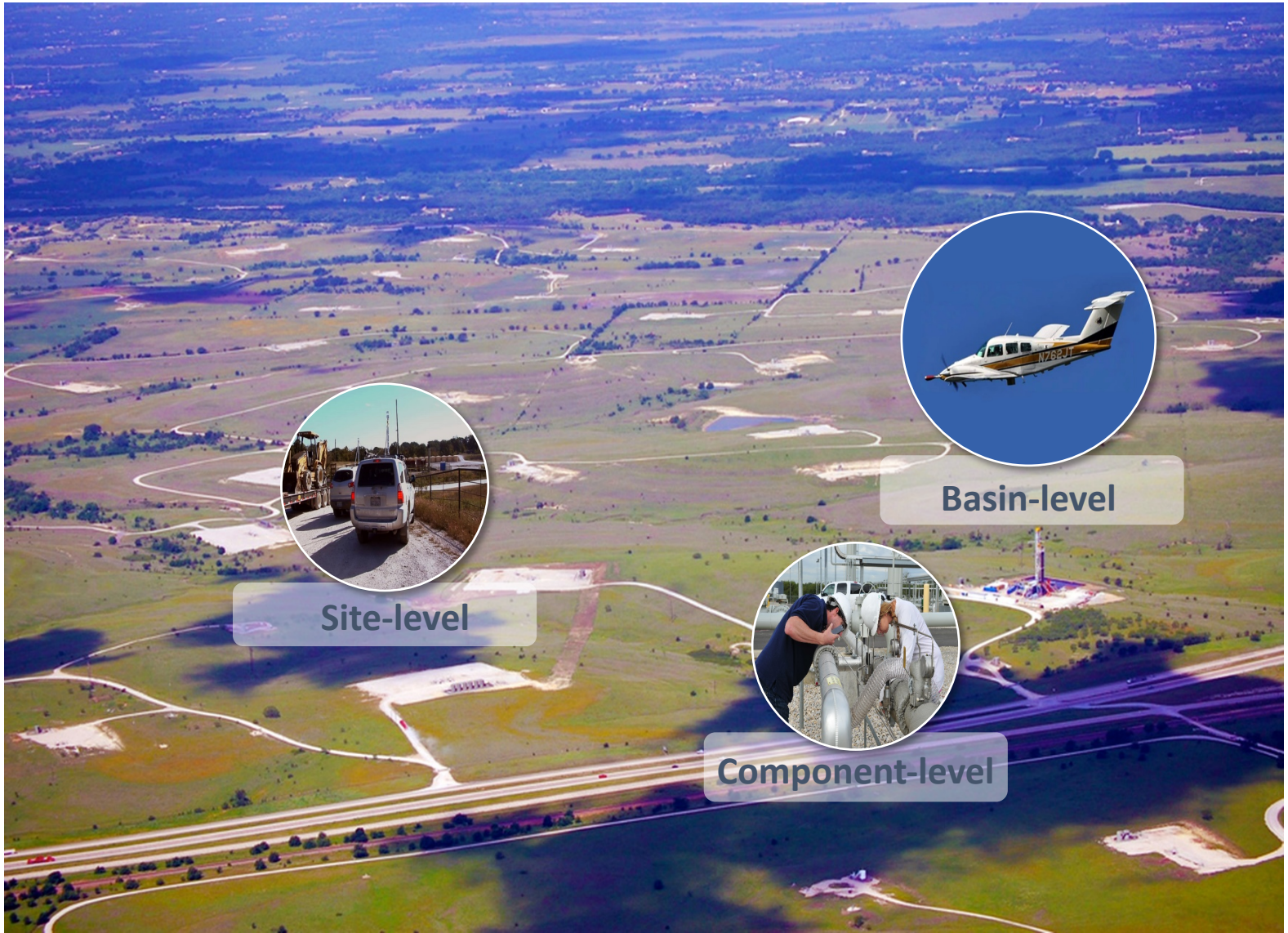
Sources of Regional Synthesis Data



Synthesis Methods

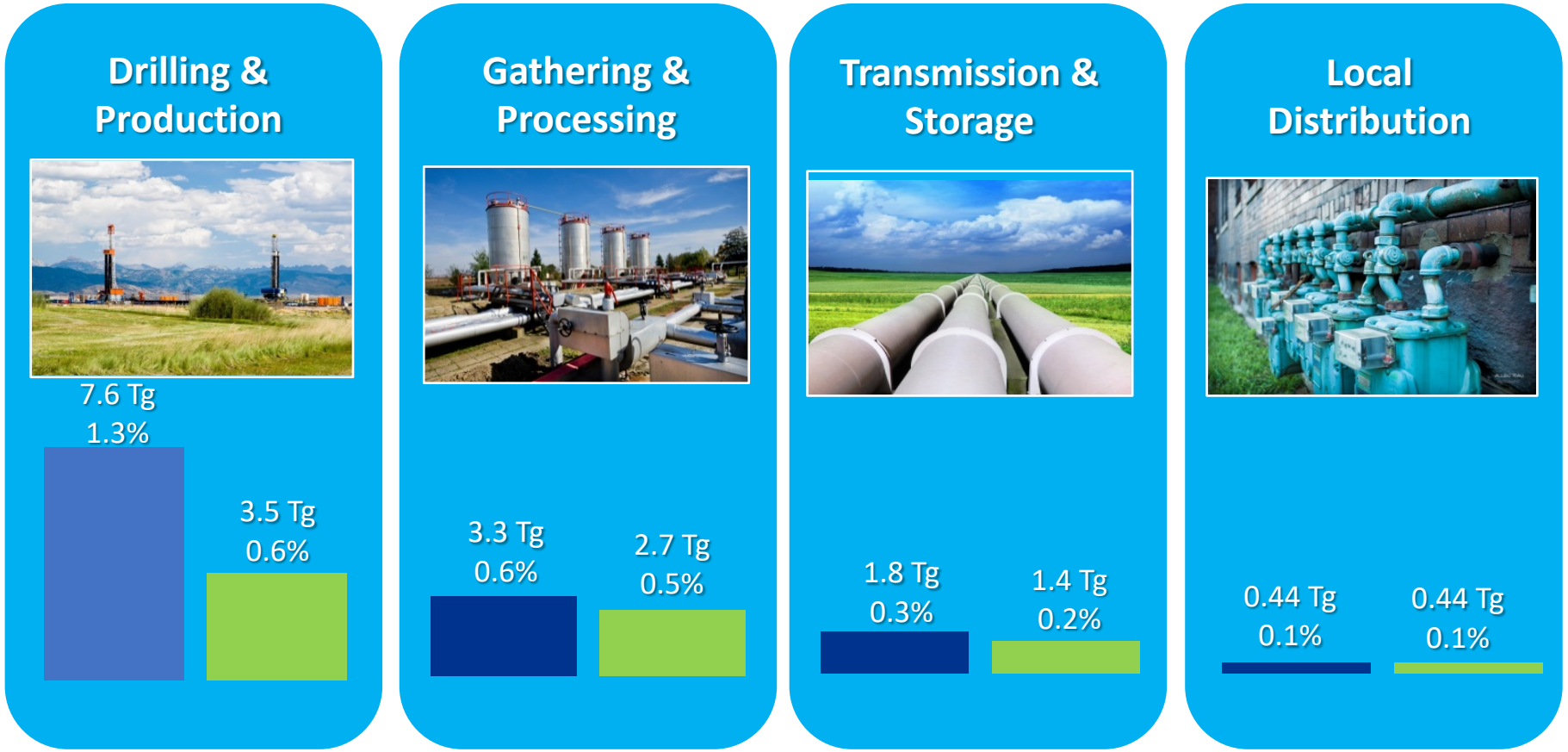
- Multiple datasets integrated to estimate 2015 U.S. methane emissions by O&G segment
  - **Production**: > 400 site-level measurements from 6 basins analyzed using a non-linear model (Omara et al 2016, Rella et al 2015, Robertson et al 2017, Brantley et al 2014)
  - **Gathering & Processing**: Marchese et al 2015
  - **Transmission & Storage**: Zimmerle et al 2015
  - **Local distribution**: Lamb et al 2015
- Estimate validated against aircraft data from 9 basins
- Estimate compared to U.S. EPA Greenhouse Gas Inventory

Basin- and site-level quantification methods find overlooked emissions by equipment-level measurements.

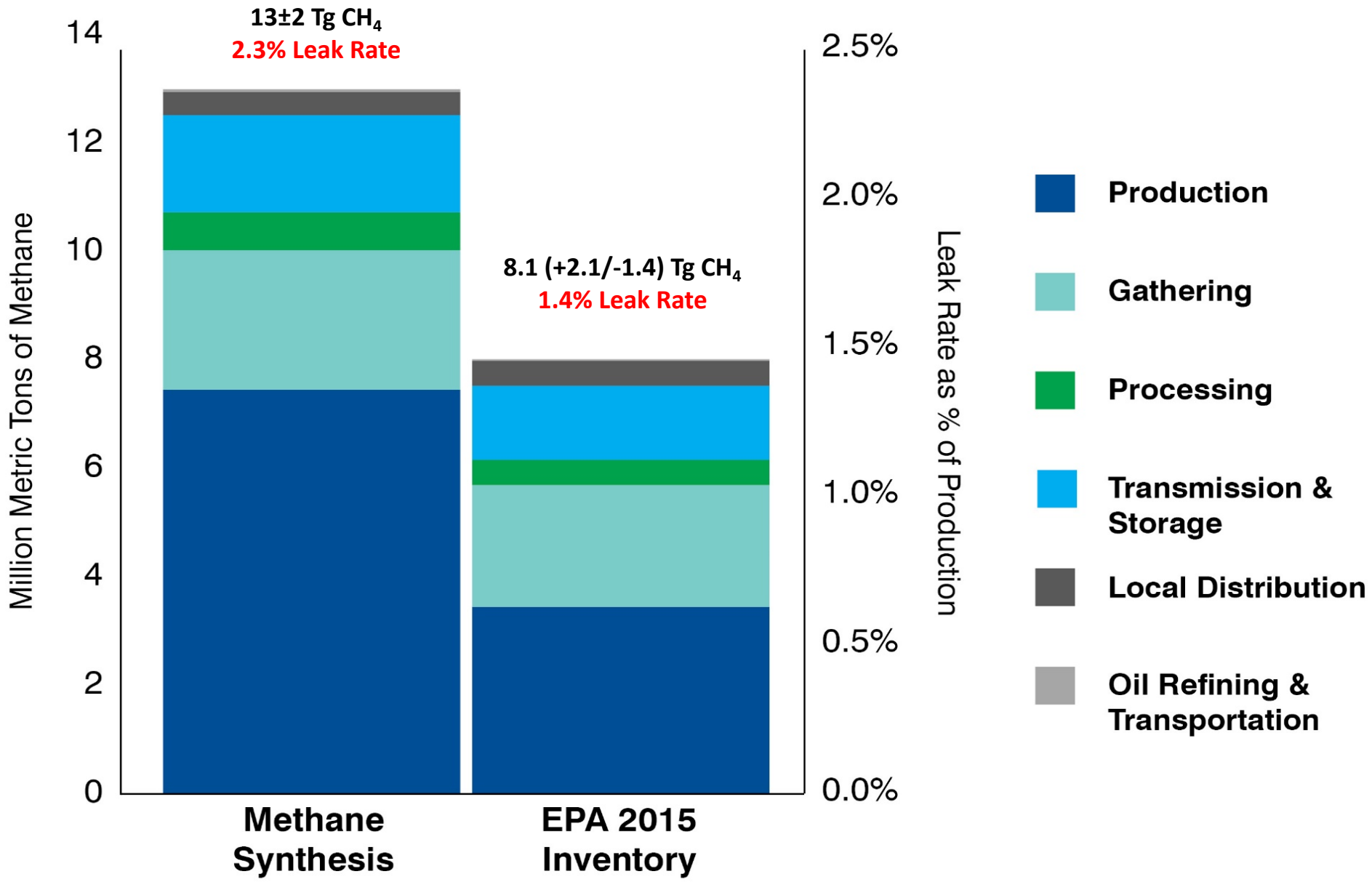


Top down vs. bottom up

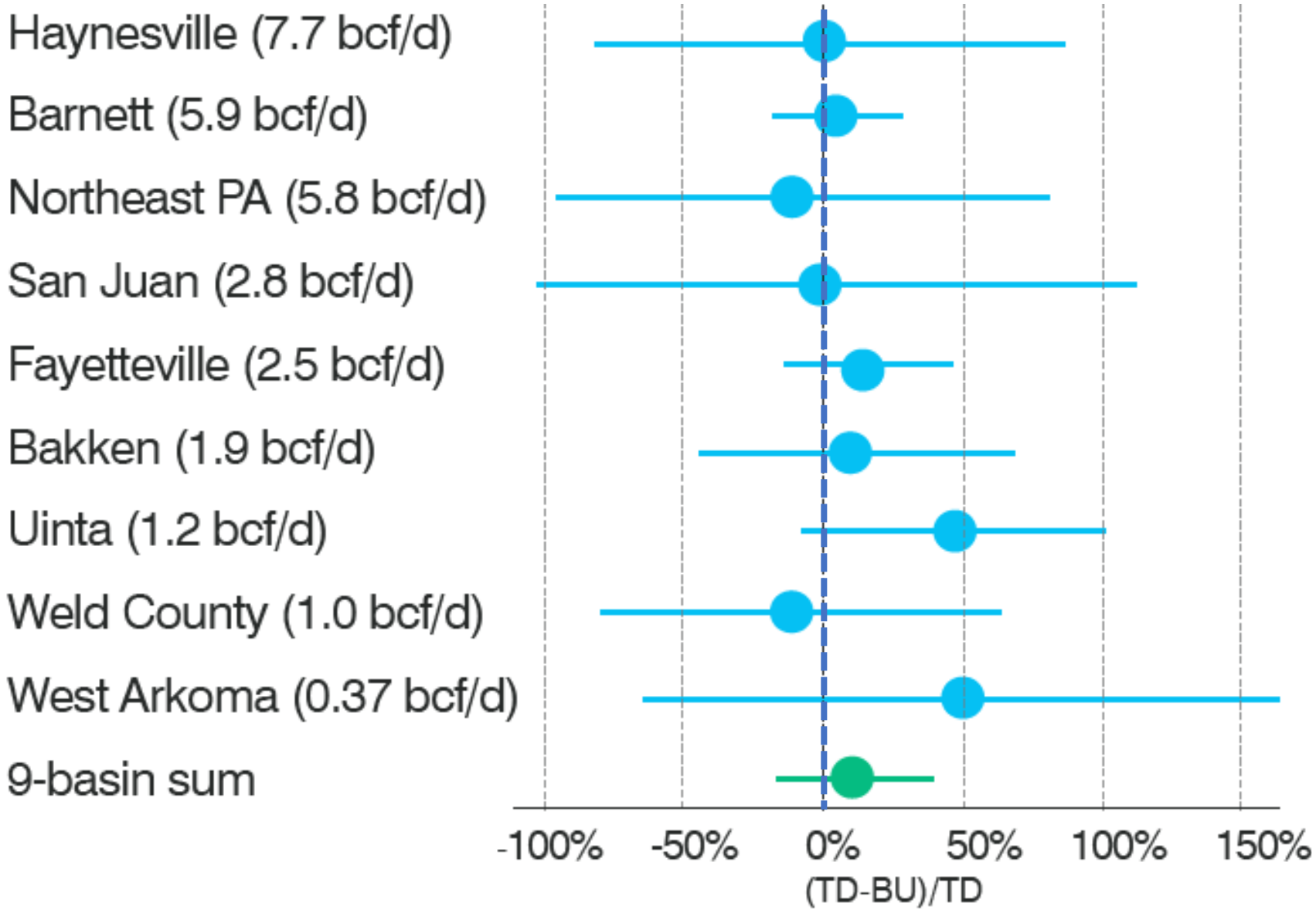
U.S. oil and gas supply chain emissions



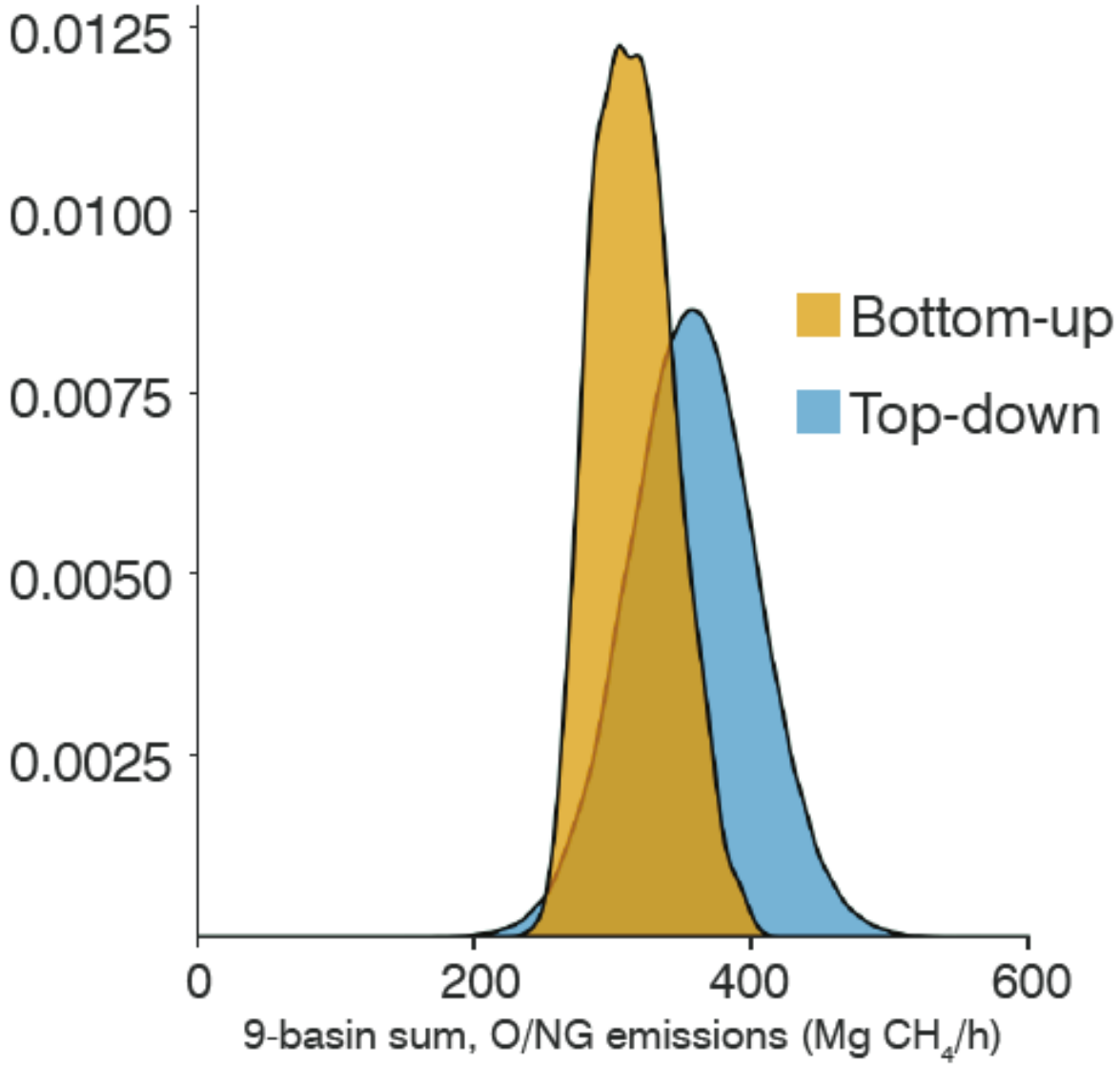
Comparing overall emissions for 2015



Basin level emissions estimates agree with top-down measurements



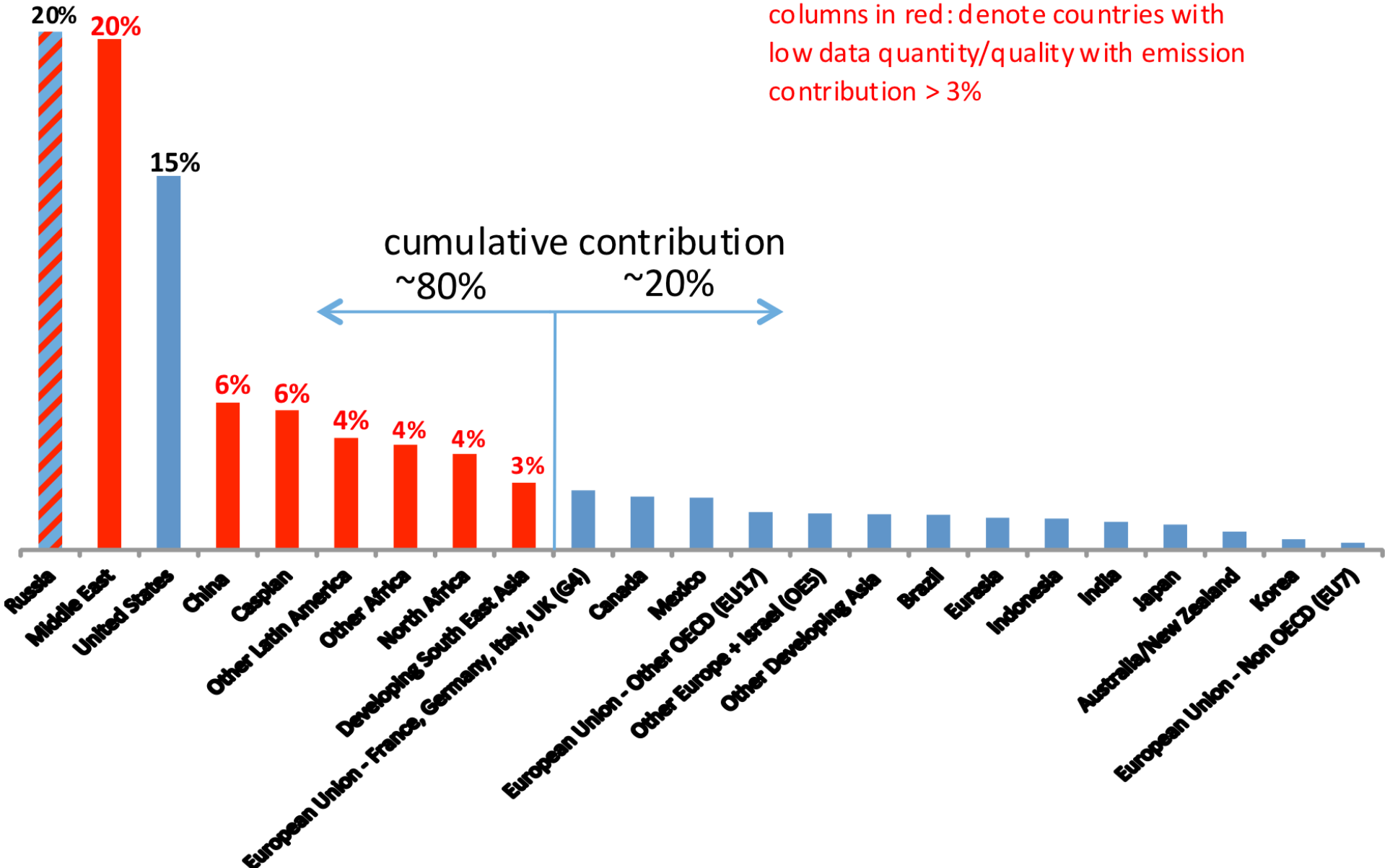
Emission estimates agree with top-down measurements from 9 basins



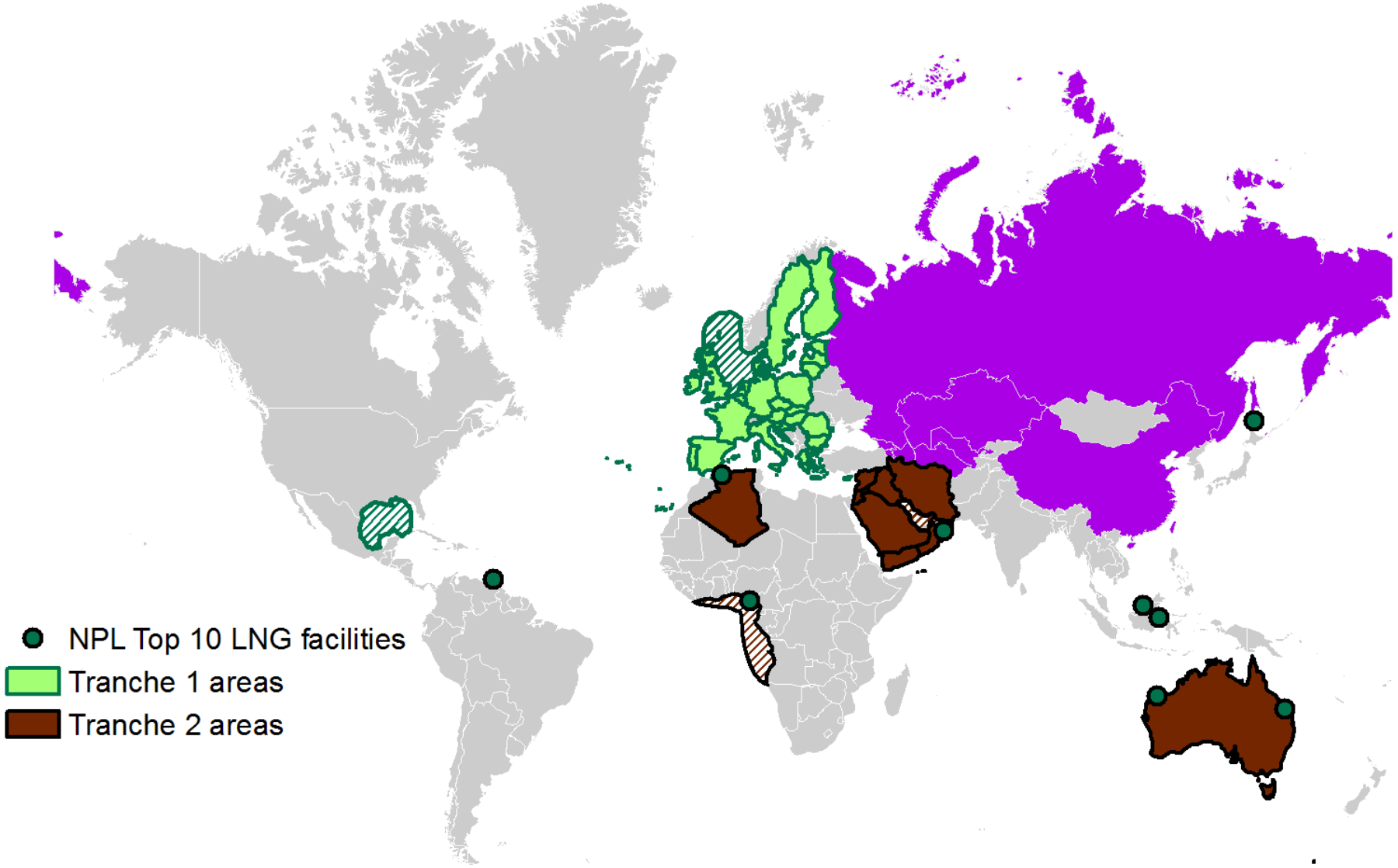
Key takeaways

- **Higher O&G methane emissions than official inventories**
  - Emissions occur across the supply chain, concentrated upstream
  - Basin-level and site-level data agree
- **Abnormal conditions responsible for a large portion of emissions**
  - These emissions are often not included in component-based inventories
  - Avoidable issues such as malfunctions, human error, and poor design can cause sites to have very high emissions
  - They make up more than half of production site emissions (about 1/3 of supply chain emissions)
- **Regulatory and voluntary actions can reduce emissions**
  - Effective monitoring to quickly detect high emissions
  - Root cause analysis and better site design to minimize the recurrence of abnormal conditions
  - Improved reporting to more accurately understand emissions

What we know about global methane emissions



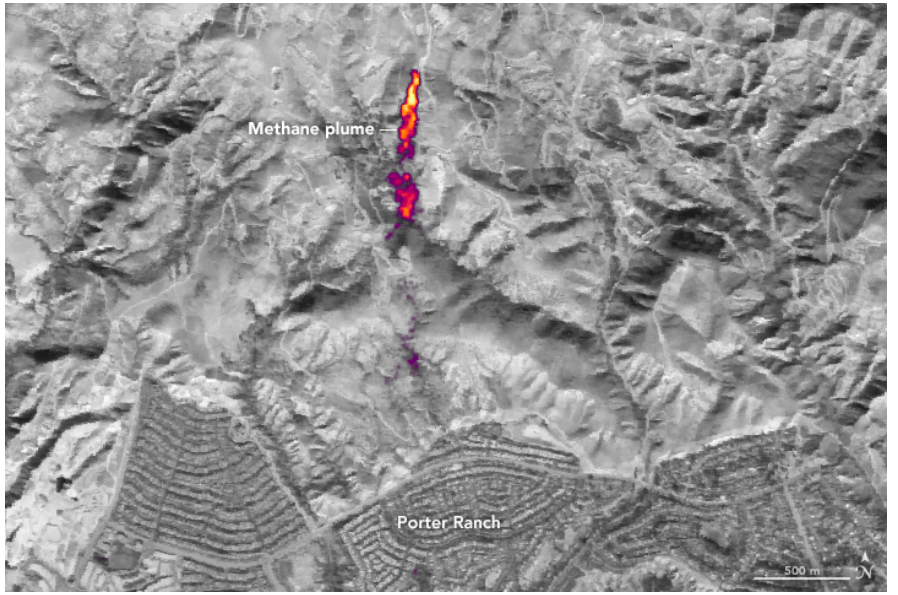
Gaps anticipated to be filled in Tranches 1 and 2



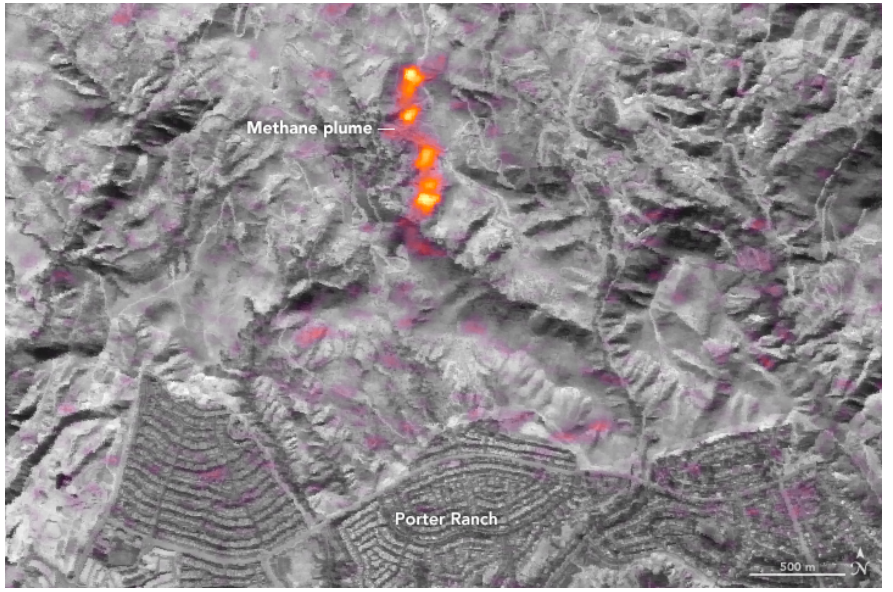
Need for High Spatial Resolution Methane Remote Sensing

Orbital and sub-orbital remote imaging spectroscopy of the Aliso Canyon blowout

Airborne AVIRIS detected methane plume

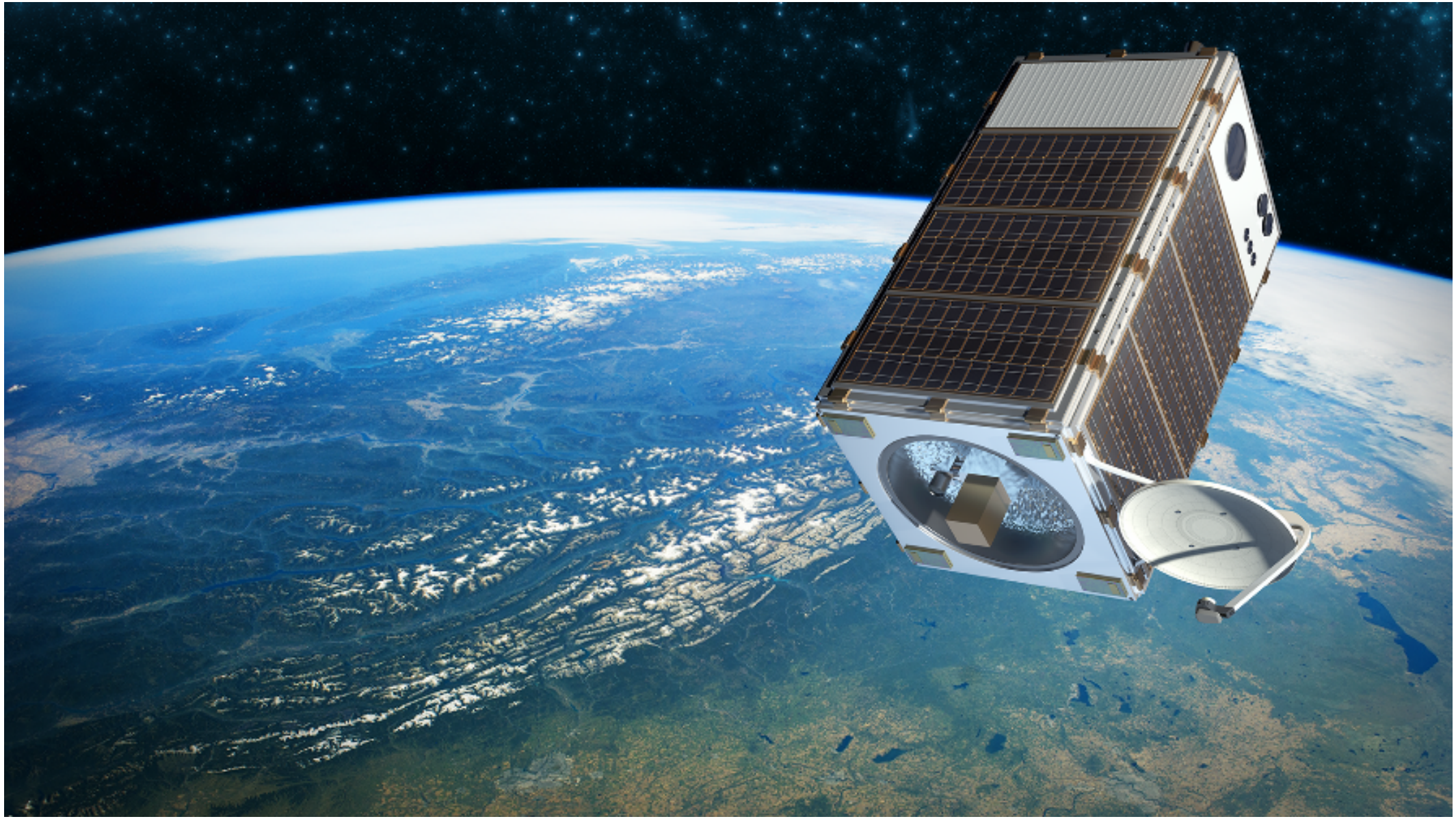


Hyperion aboard EO-1 satellite methane detection



Thompson et al. 2016 (GRL)

MethaneSAT: Ability to collect Data more rapidly



Funding

- Funding for EDF's portion of this methane research series was provided by Fiona and Stan Druckenmiller, Heising-Simons Foundation, Bill and Susan Oberndorf, Betsy and Sam Reeves, Robertson Foundation, Alfred P. Sloan Foundation, TomKat Charitable Trust, and the Walton Family Foundation.

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