

DOCKETED

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Methane Sources and Emissions



Photo: R. Jackson, USA Today

California Air Resources Board, June, 2016

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Energy-Water Interactions (not discussed today)



Global Carbon Project (globalcarbonproject.org)



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The Global Carbon Project

The Global Carbon Project (GCP) was established in 2001 in recognition of the large scientific challenges and critical nature of the carbon cycle for Earth's sustainability.

The scientific goal of the project is to develop a complete picture of the global carbon cycle, including both its biophysical and human dimensions together with the interactions and feedbacks between them.

Tribute to
Mike Raupach



Managing the Carbon
Cycle Requires Strong
Science



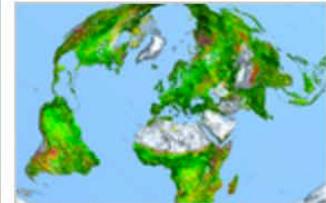
10th International CO₂
Conference (ICDC)
21-25 August 2017



Science Highlights



[Carbon Budget 2015](#)



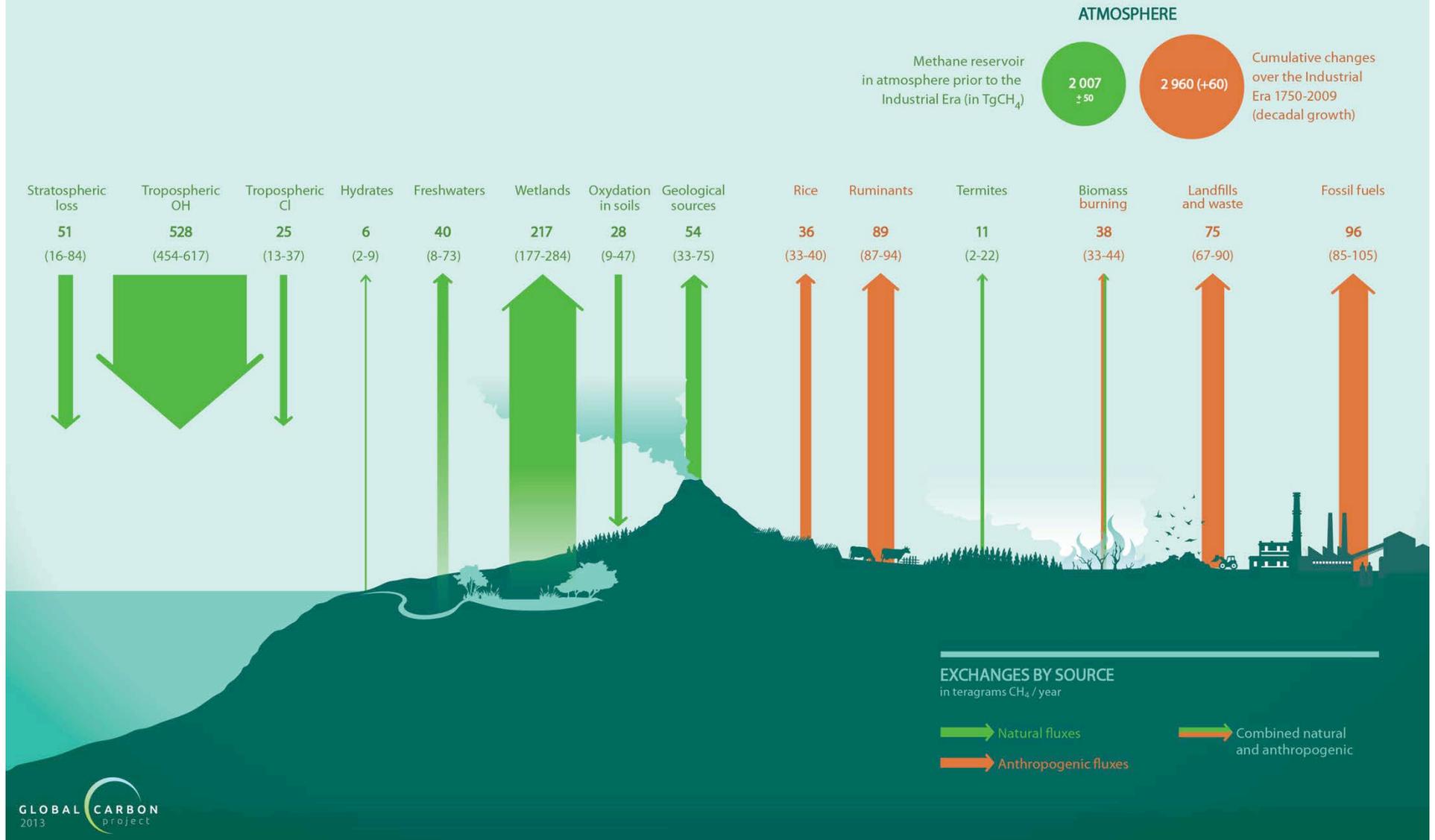
[Greening Earth](#)



[Land is a GHG source](#)

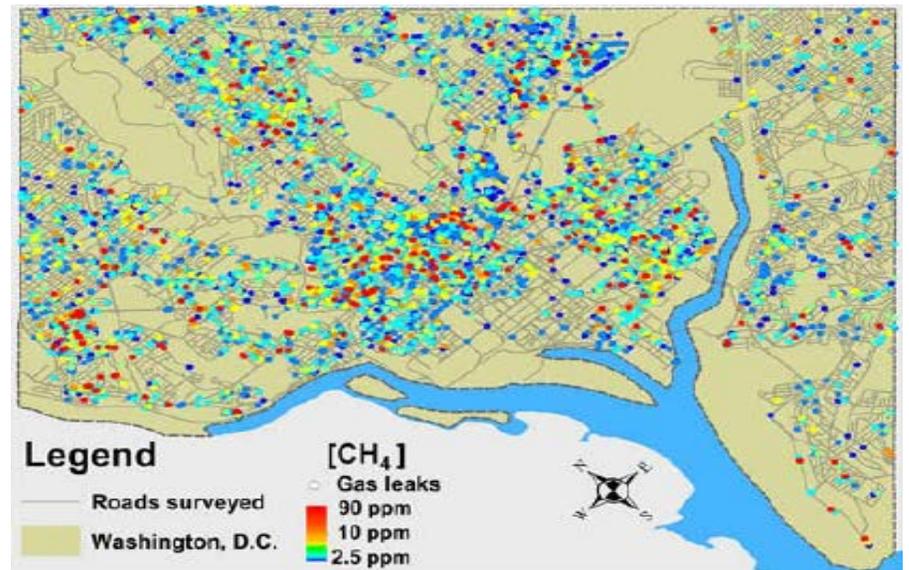
Global Methane Budget (2nd budget just submitted)

METHANE BUDGET : 2000-09



Based on Kirschke et al. 2013, Nature Geoscience

Air Studies Upstream at Wellpads and Downstream to City Streets





Air Quality and Health Interactions

On-site Workers

Compressor Stations

Drilling & Well Completions

Holding Ponds

Winter Ozone Formation



How Common Are Large Emitters? Early Detection is Key



N. 33.06607 97.39993

Well Pad Location - Big Leaks

2 Hatch Leaks - from

top of Black Tanks

Flights across six regions and >8,000 wellpads (with EDF).

- 1) The % of sites with large emissions was 4% nationally, ranging from 1% in the Powder River (WY) to 14% in the Bakken (ND).
- 2) Emissions observed 3x more often in oil-producing plays & in oil-producing regions of mixed basins. In the Barnett, 21% of well pads producing oil emitted methane compared with <1% of gas sites.
- 3) >90% of ~500 detected sources were from tank vents & hatches.



(Lyon et al. 2016 ES&T)



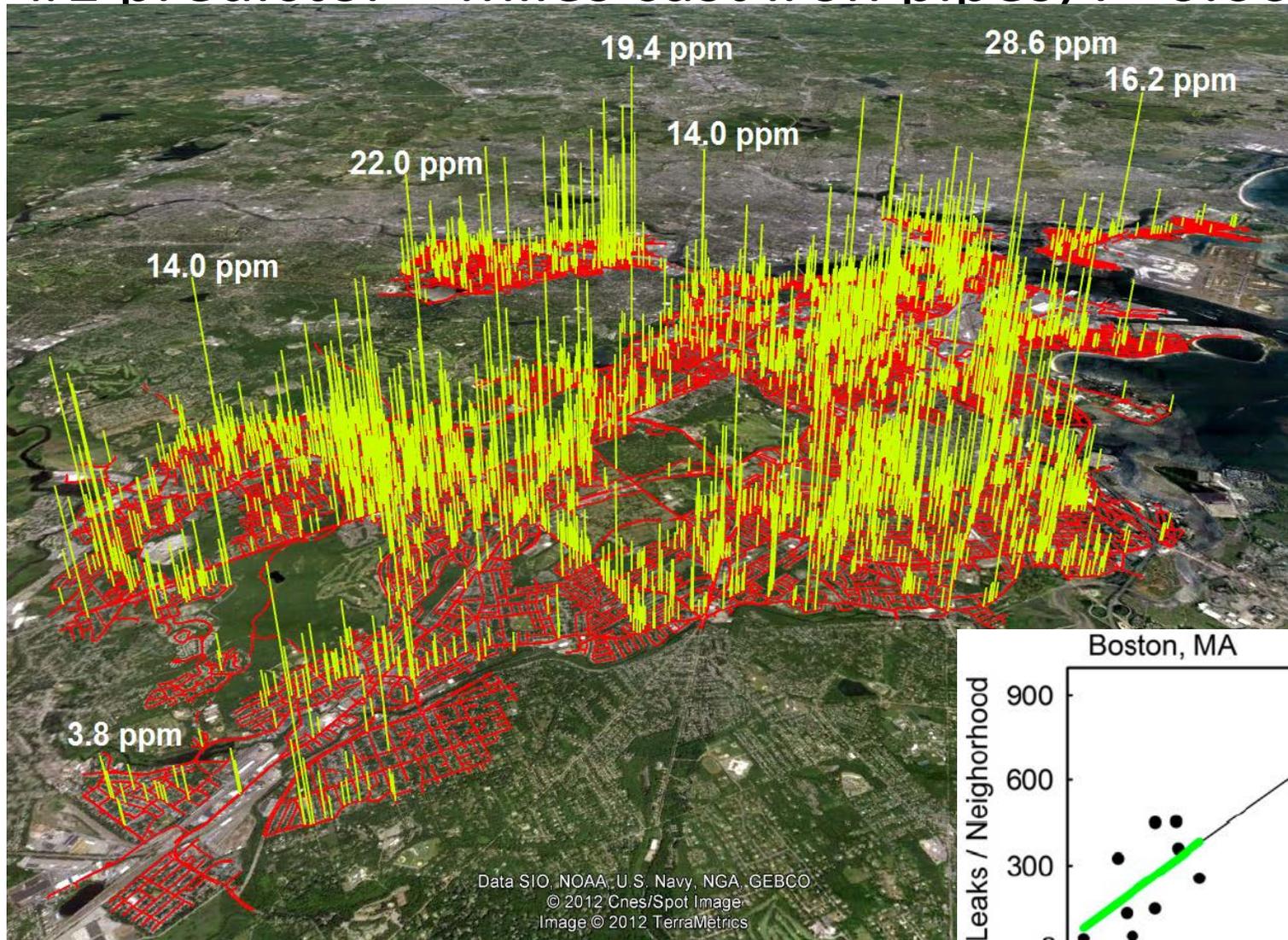
Legacy Wells : What Happens in 25 or 50 Years?



Methane losses from pipelines downstream



Boston overall (~3,400 leaks; 800 road miles)
#1 predictor – miles cast iron pipes; $P < 0.001$



Red = roads driven; Yellow = leaks
Phillips et al. 2013 Env Pollution

Some Quick Responses

Boston Mayor Tom Menino

Mayor Menino has written a strongly worded letter to the state Department of Public Utilities urging its chairwoman to step up scrutiny of utilities following a story in today's Globe about more than 3,300 natural gas leaks from the vast pipeline system under Boston.

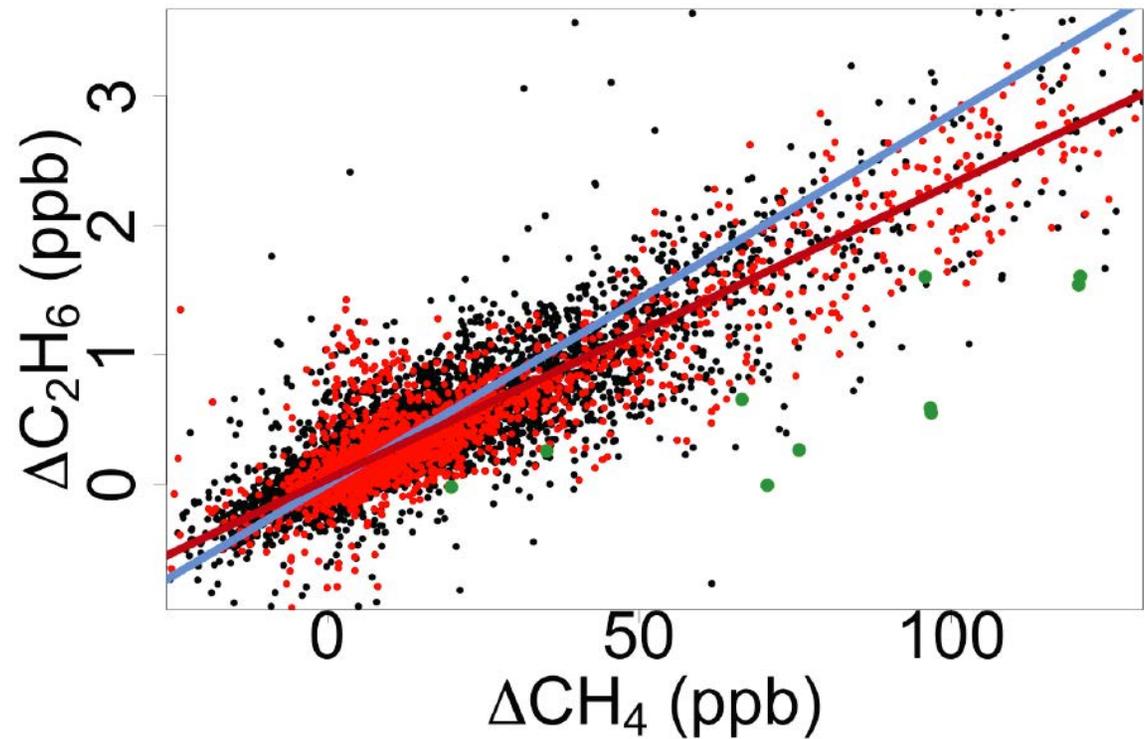
Congressman Ed Markey, MA 7th District

“This study shows that we need a plan to ensure leaks from aging natural gas pipelines in Boston and other cities and communities are repaired, so that we can conserve this important natural resource, protect the consumers from paying for gas that they don't even use, and prevent emissions of greenhouse gases into the environment,” Markey wrote to the Pipeline and Hazardous Materials Safety Admin.

July, 2014: Massachusetts passes new pipeline safety bill that includes accelerated natural gas pipeline replacements.

How much natural gas is in the air of the Boston metroplex?

Top-down CH₄ budget : $18.5 \pm 3.7 \text{ g CH}_4 \text{ m}^{-2} \text{ yr}^{-1}$
~90% natural gas in winter, ~60% in summer
(2.7% loss, ~ 2.5X higher than state inventory)

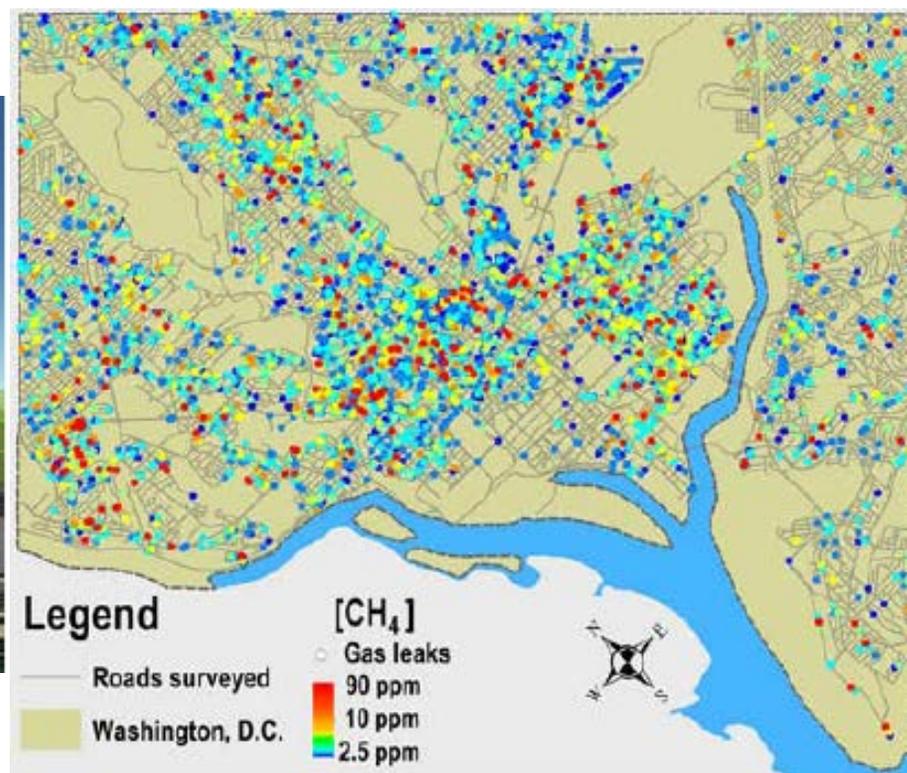
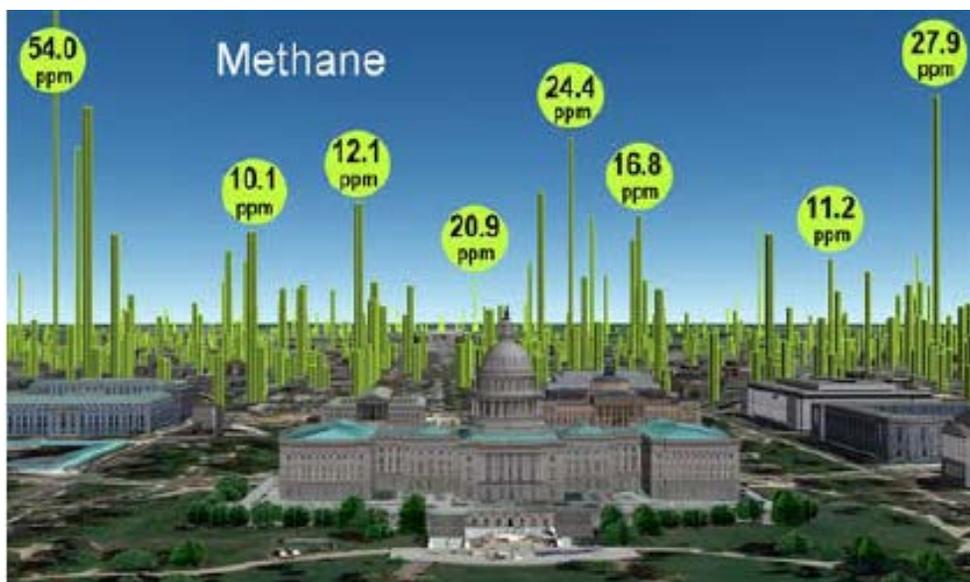


McKain et al. 2015 PNAS

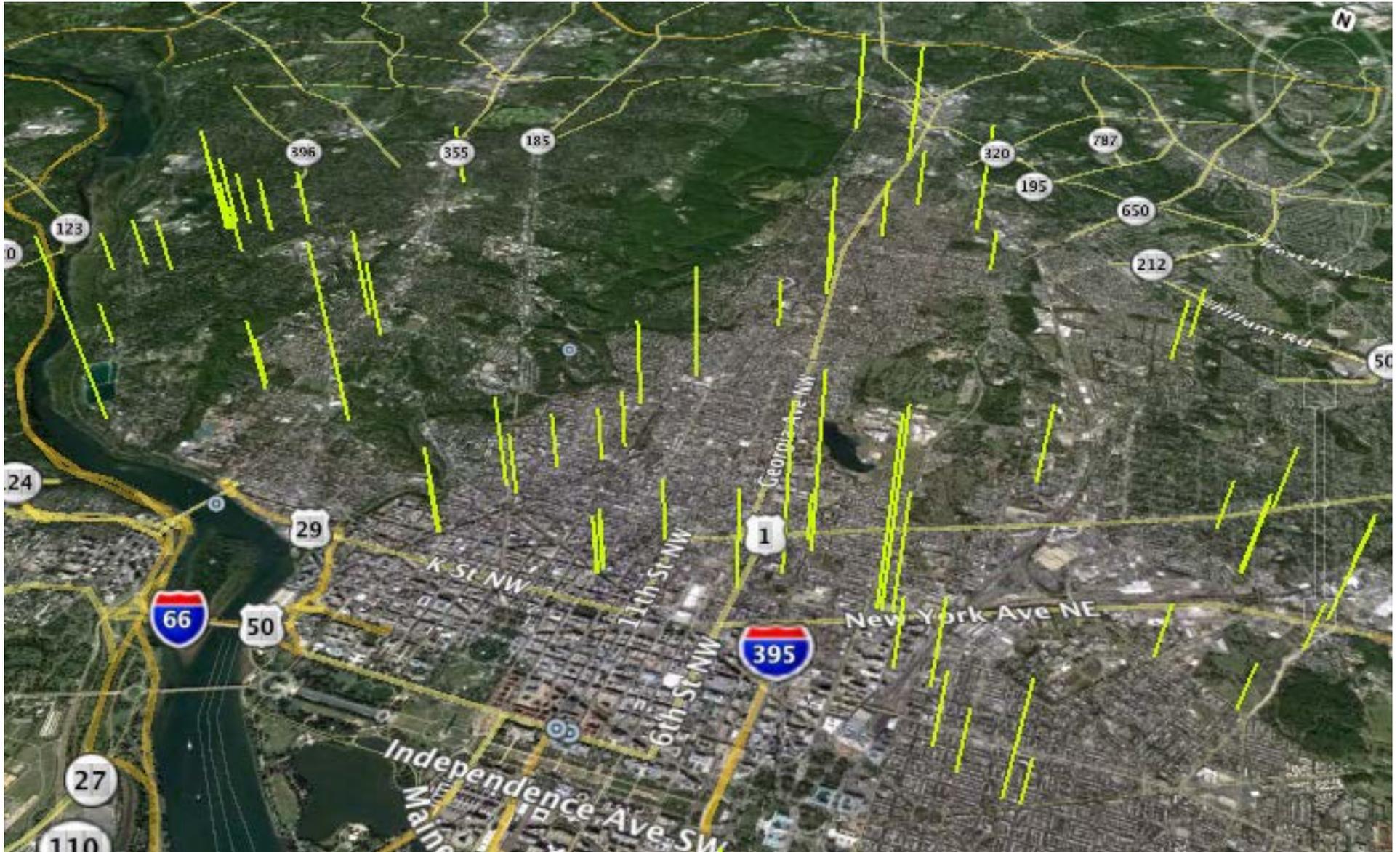
Published in 2014: Map of ~6,000 Methane Leaks in DC

Natural Gas Pipeline Leaks Across Washington, DC

Robert B. Jackson,^{†,‡,*} Adrian Down,[†] Nathan G. Phillips,[§] Robert C. Ackley,^{||} Charles W. Cook,[†]
Desiree L. Plata,[⊥] and Kaiguang Zhao[†]



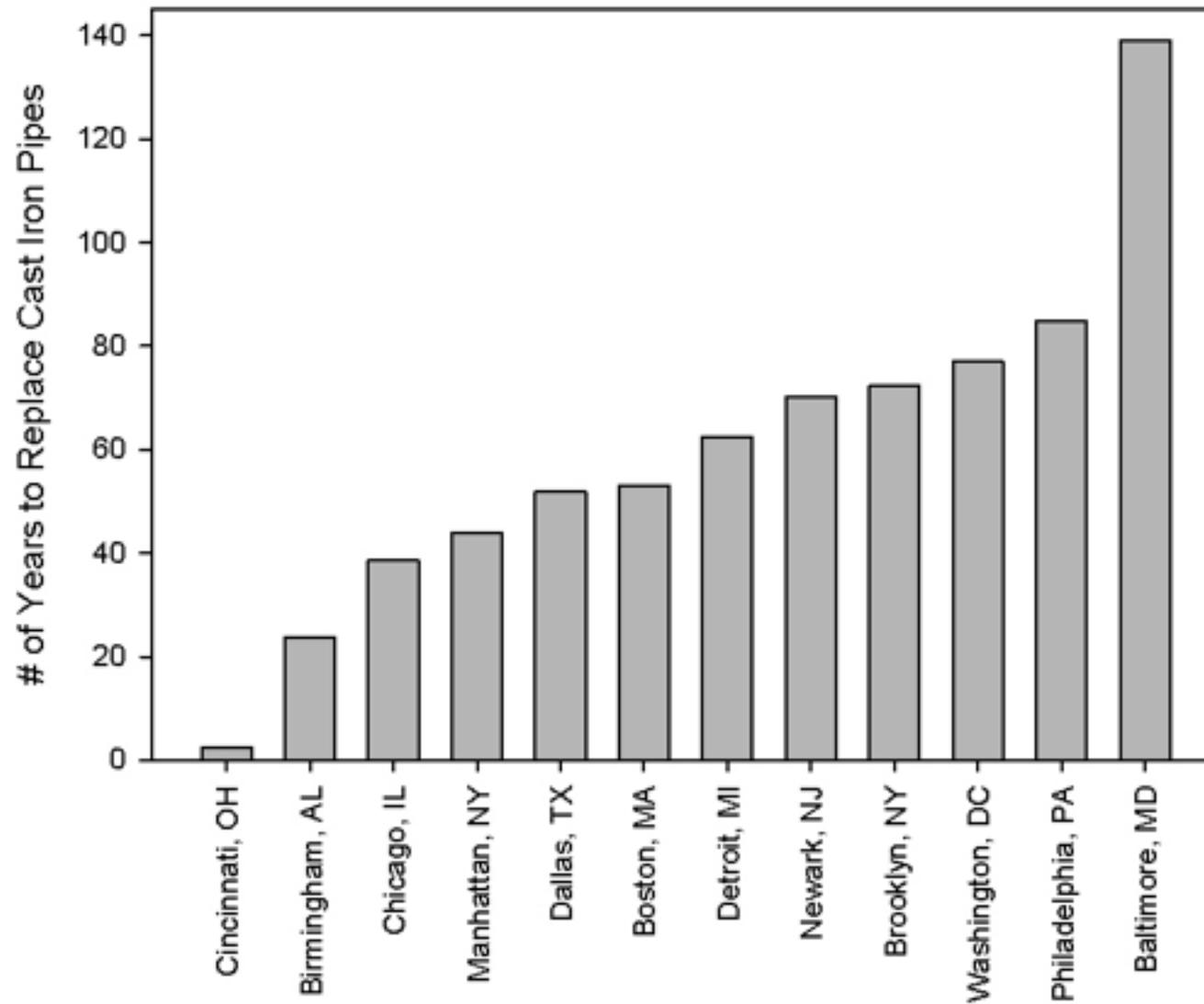
We can identify the top 50 leaks, for instance, all of them between 30 and 100 ppm methane (50-times background)



Jackson et al. 2014

Who's Doing a Good Job?

Years to Full Replacement of Cast-Iron Pipes



Estimates based on PHMSA data for 2004-2013

Jackson et al. 2014
Ann Rev Env Res

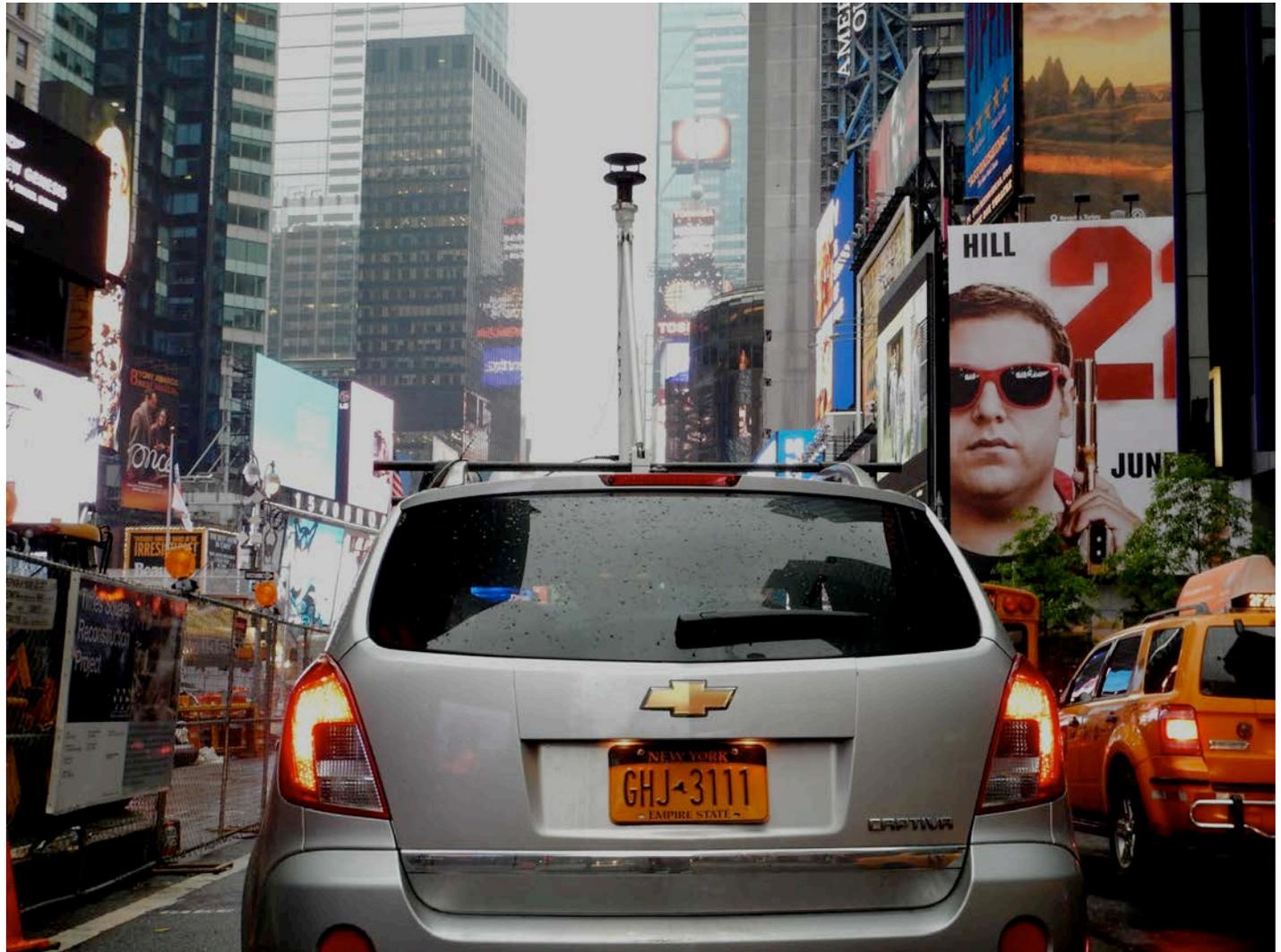
Natural Gas Pipeline Replacement Programs Reduce Methane Leaks and Improve Consumer Safety

Morgan E. Gallagher,^{†,‡} Adrian Down,[§] Robert C. Ackley,^{||} Kaiguang Zhao,[⊥] Nathan Phillips,[#]
and Robert B. Jackson^{*,†,▽}

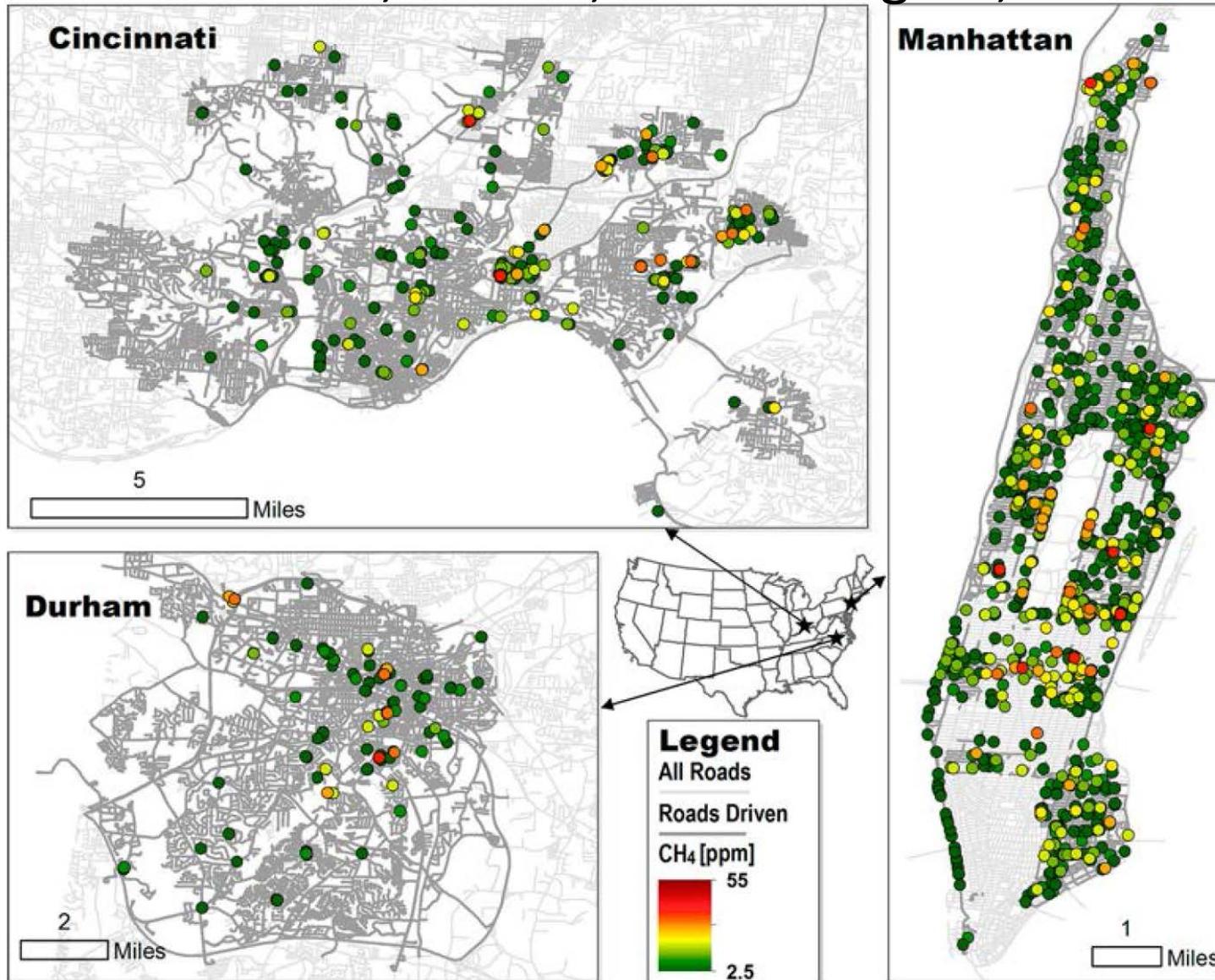


Published last fall

Mapped three new cities: Manhattan, Cincinnati, and Durham, NC.



90-95% fewer leaks in Cincinnati or Durham, NC, cities with completed pipeline replacement programs, than in Manhattan, Boston, or Washington, DC.



Gallagher
et al. 2015

Justifications for Fixing Leaks:

- 1) Money: Consumers pay ~\$2 billion each year in LAU gas
- 2) Jobs: Four unions benefit from repairing and replacing pipelines: UA (pipefitters), LIUNA, Operating Engineers, and Teamsters.
- 3) Consumer safety: ~15 fatalities and \$130 M in property damage annually from incidents
- 4) Air Quality and Health: Volatile organics and ozone formation
- 5) Greenhouse gas emissions and climate change