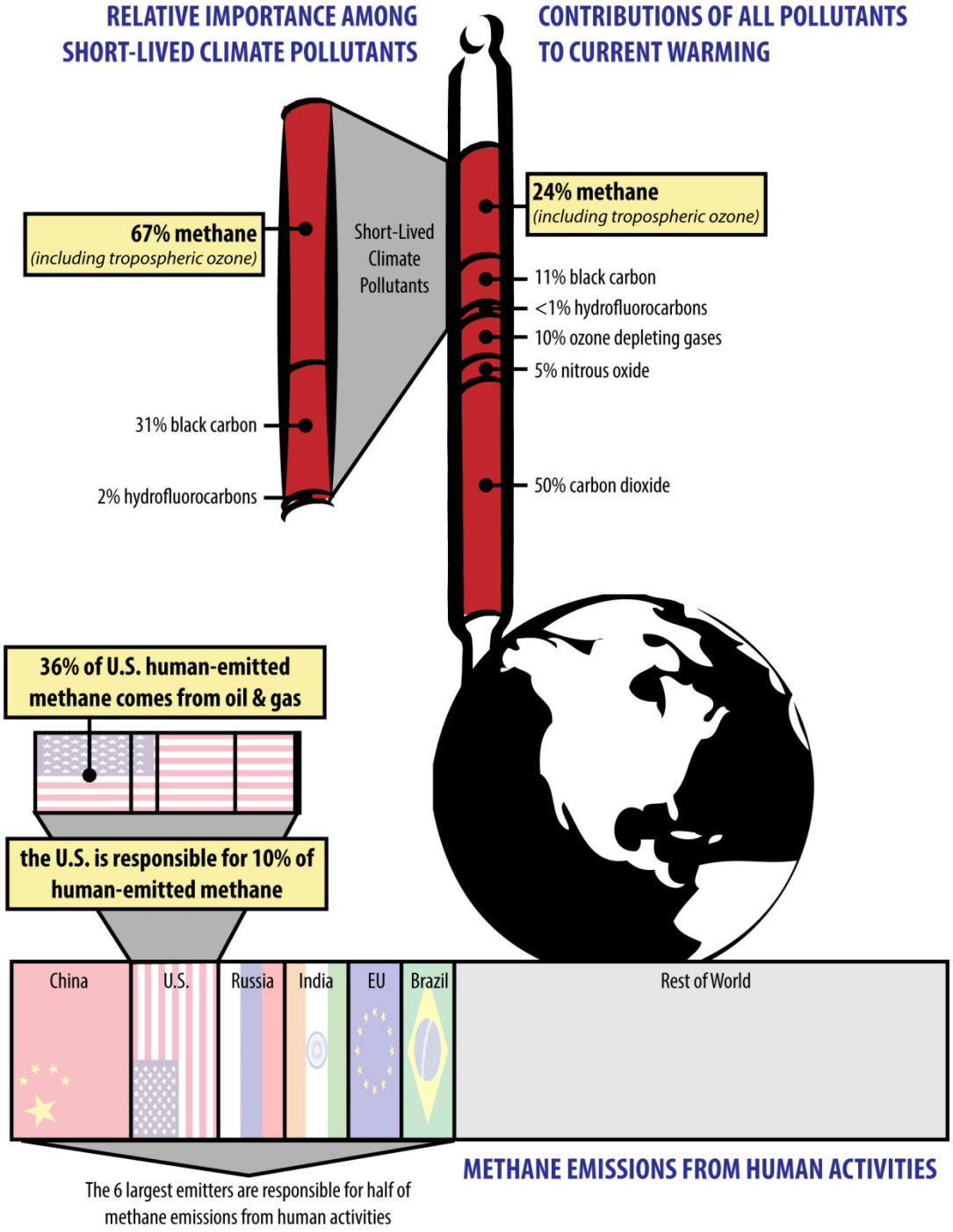
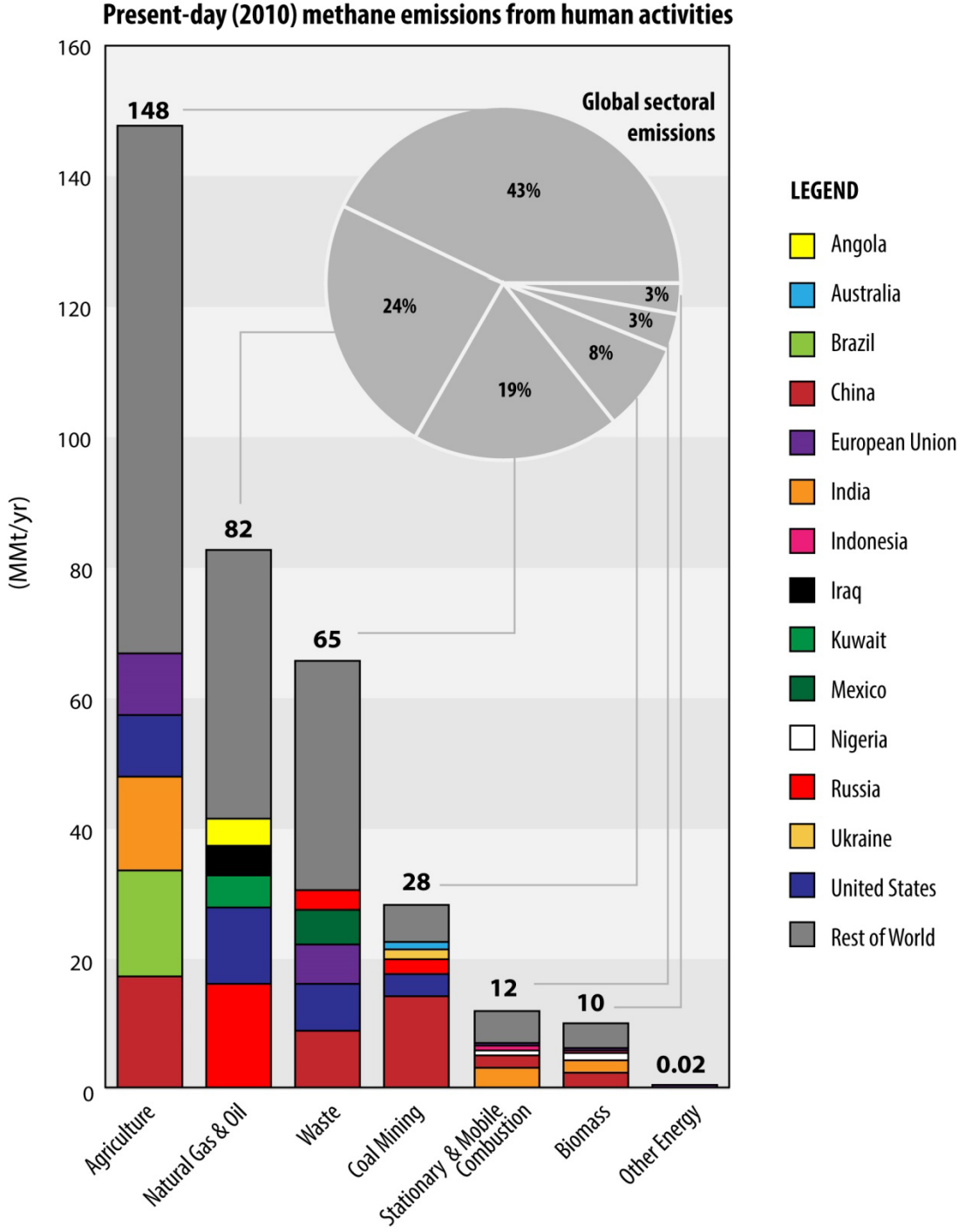
Challenges and Opportunities in non-CO_2 GHG Measurements and Standards: Natural Gas Case Study

Steven Hamburg
Chief Scientist

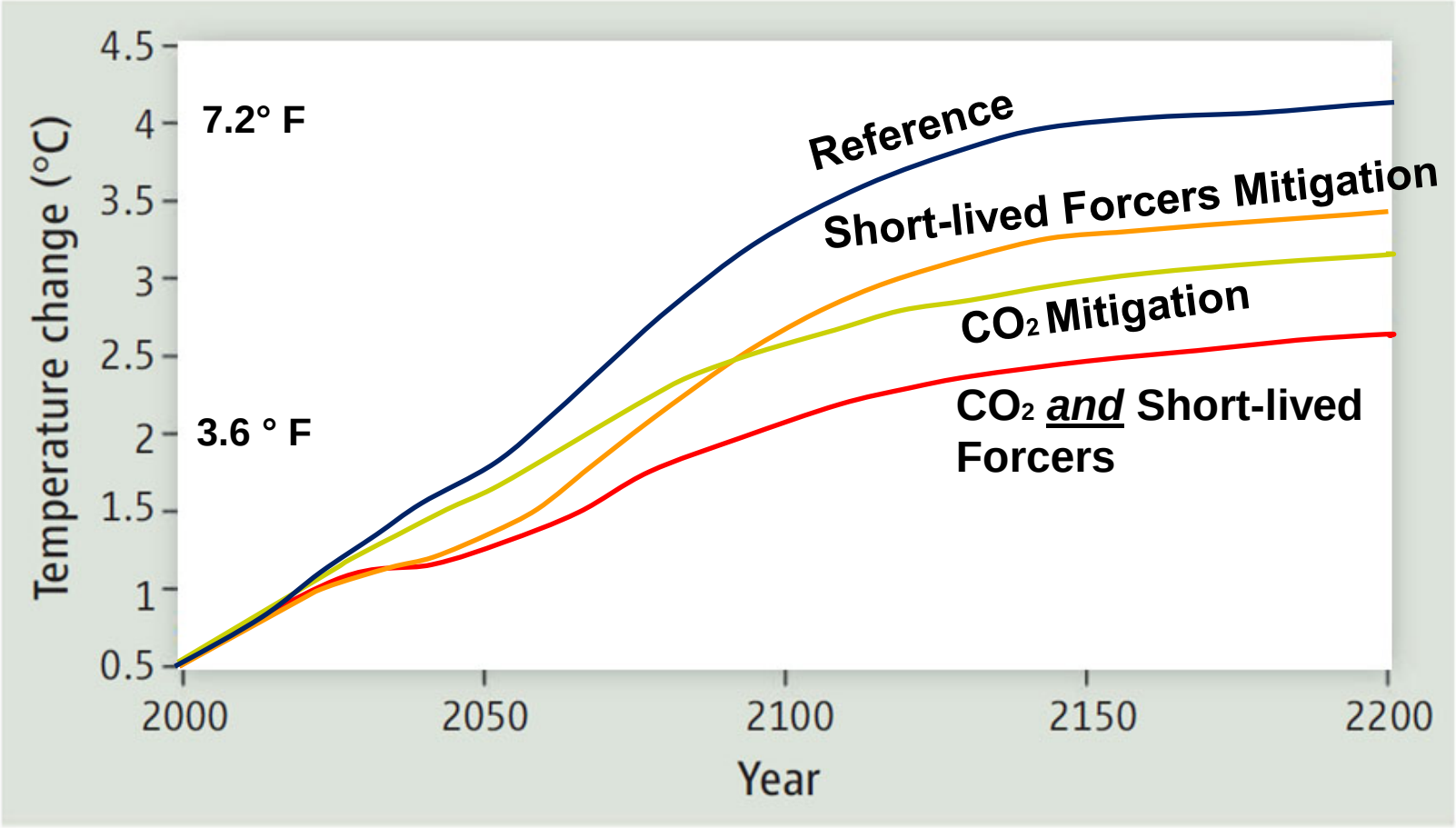
BIPM Workshop
June 30, 2015

EDF
ENVIRONMENTAL DEFENSE FUND®
Finding the ways that work


RELATIVE IMPORTANCE AMONG SHORT-LIVED CLIMATE POLLUTANTS
CONTRIBUTIONS OF ALL POLLUTANTS TO CURRENT WARMING
67% methane (including tropospheric ozone)
Short-Lived Climate Pollutants
31% black carbon
2% hydrofluorocarbons
24% methane (including tropospheric ozone)
11% black carbon
<1% hydrofluorocarbons
10% ozone depleting gases
5% nitrous oxide
50% carbon dioxide
36% of U.S. human-emitted methane comes from oil & gas
the U.S. is responsible for 10% of human-emitted methane
China
U.S.
Russia
India
EU
Brazil
Rest of World
The 6 largest emitters are responsible for half of methane emissions from human activities
METHANE EMISSIONS FROM HUMAN ACTIVITIES


Present-day (2010) methane emissions from human activities
(MMt/yr)
160
140
120
100
80
60
40
20
0
148
82
65
28
12
10
0.02
Agriculture
Natural Gas & Oil
Waste
Coal Mining
Stationary & Mobile Combustion
Biomass
Other Energy
Global sectoral emissions
43%
24%
19%
8%
3%
3%
LEGEND
Angola
Australia
Brazil
China
European Union
India
Indonesia
Iraq
Kuwait
Mexico
Nigeria
Russia
Ukraine
United States
Rest of World

Reduce Methane *and* CO2



Atmospheric lifetimes affect climate change rate and magnitude

Short-lived Climate Pollutants (SLCPs)

Immediate impact for days to decades—doesn't accumulate

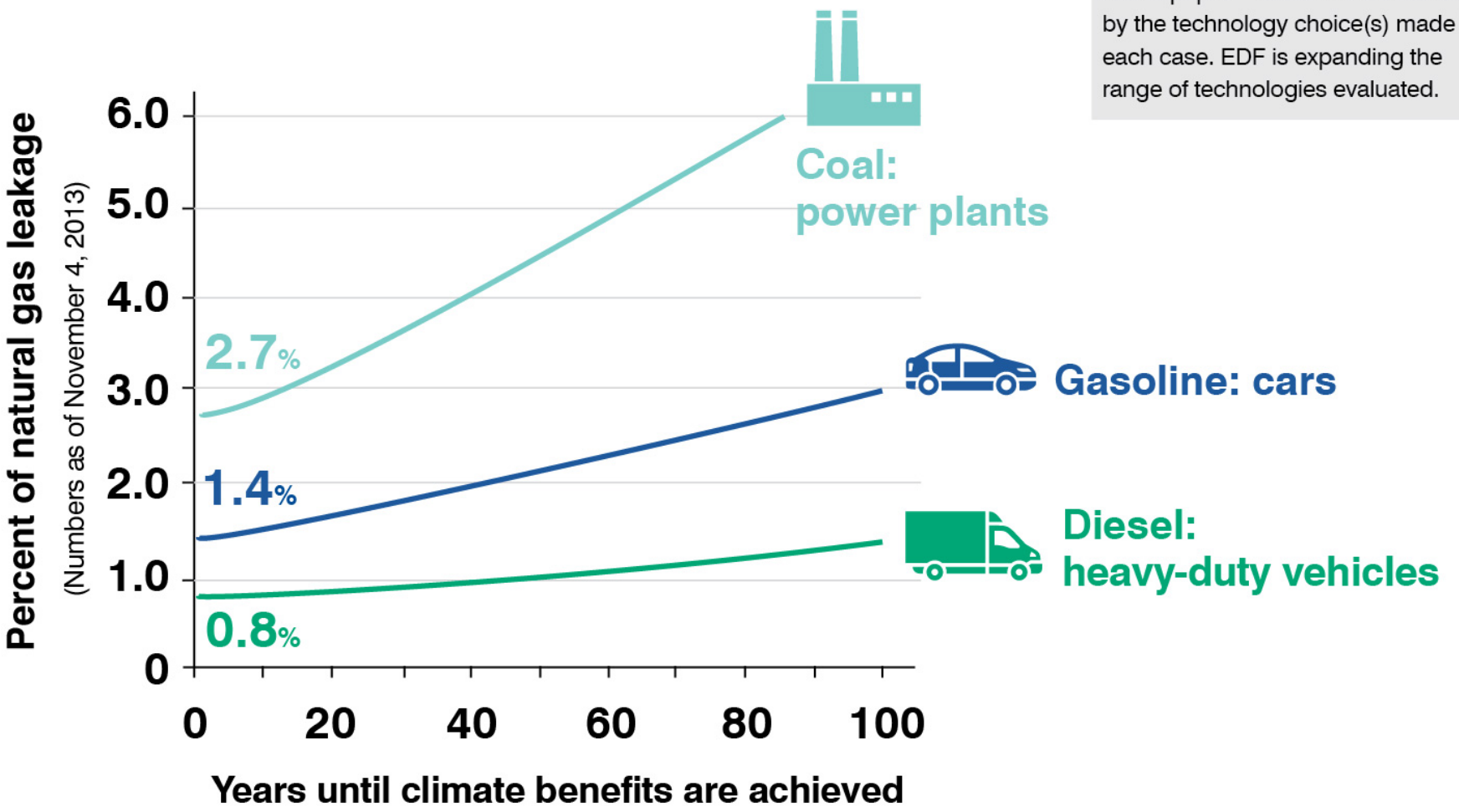
Long-lived Climate Pollutants (LLCPs)

Persistent climate impacts over centuries to millennia—accumulates over time

More details in notes

Can Natural Gas Deliver Sustained Climate Benefits?

Updated calculations 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®
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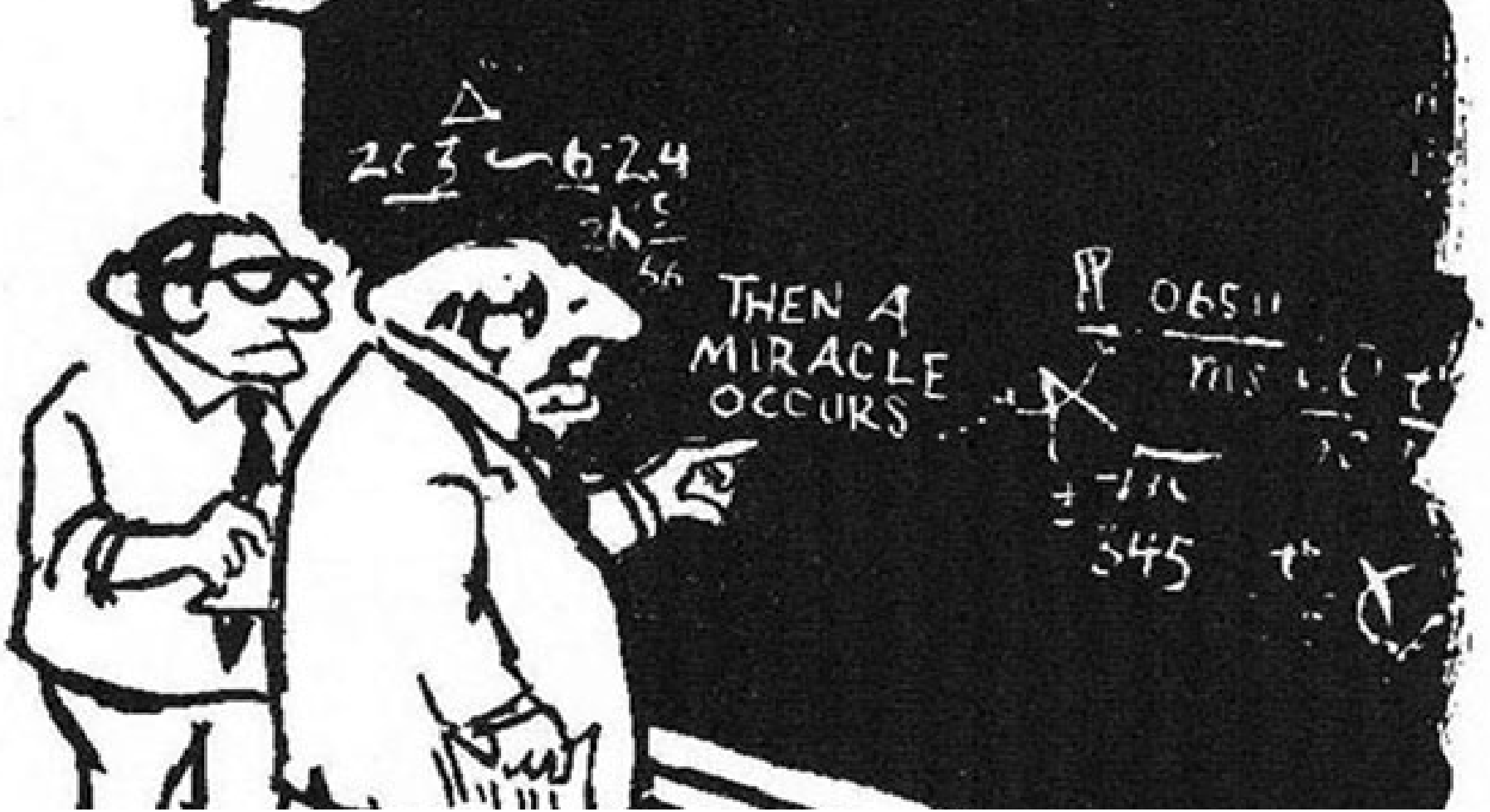
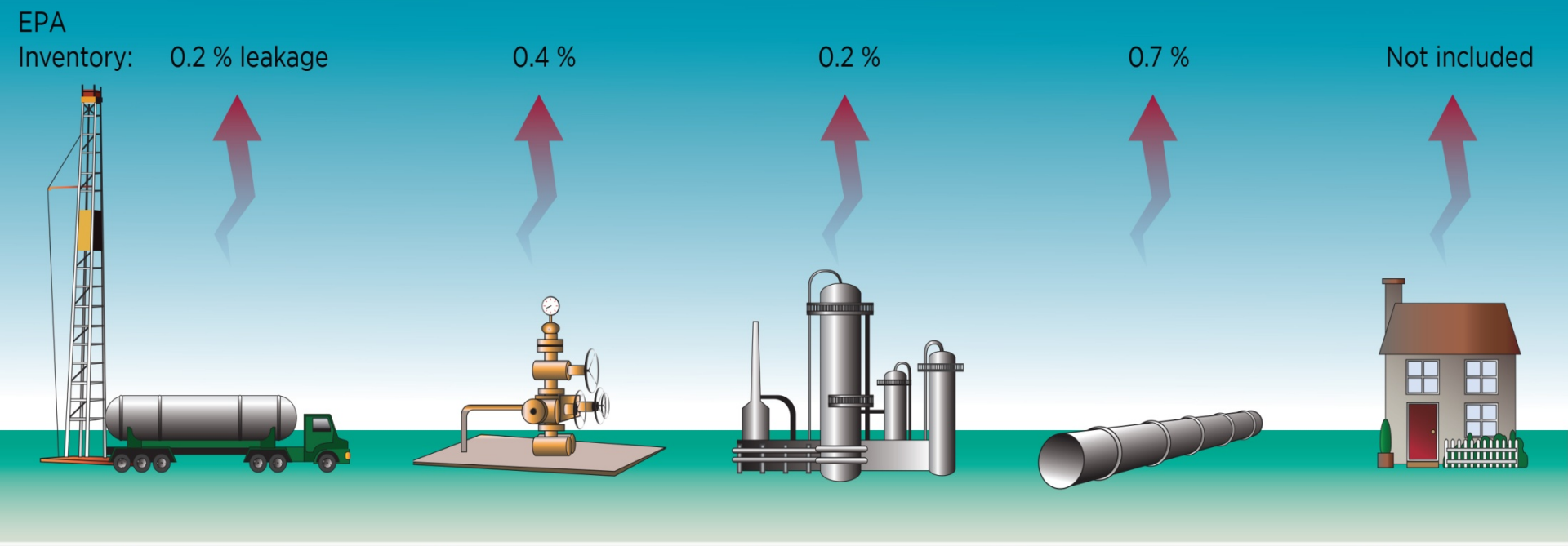
**Adapted from Alvarez et al. (2012) PNAS, 109: 6435–6440, reflecting new IPCC AR5 & 2013 EPA GHG data. IPCC updates: (1) direct/indirect radiative forcing of CH_4 and CO_2, (2) CH_4 lifetime, (3) CO_2 impulse response function. Additional effects due to climate-carbon feedbacks and CO_2 from the oxidation of CH_4 not included. AR5 lacks data for further time-dependent analysis but EDF believes these effects to be small. Emissions updates included 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.*



“I think you need to be more specific in step 2”

United States Methane Leakage Rates from the Natural Gas System



Drilling and fracturing | Production | Processing | Transportation and distribution | End use

Total NG leakage - EPA: 1.5 %

Evidence from other Studies

- Nationwide, NGML/EPA, 2006 ↔
- Nationwide, GTI, 2009 ↔
- Los Angeles, CARB/UC Irvine/NOAA, 2010 ↑
- Texas & New Mexico, URS/U. Texas, 2011 ↔
- Colorado, NOAA, 2012 ↑
- Los Angeles, Caltech, 2012 ↑
- Nationwide, Harvard, 2013 ↑
- Los Angeles, CU Boulder, 2013 ↑
- Utah, NOAA, 2013 ↑
- Nationwide, U. Texas, 2013 ↔

LEGEND

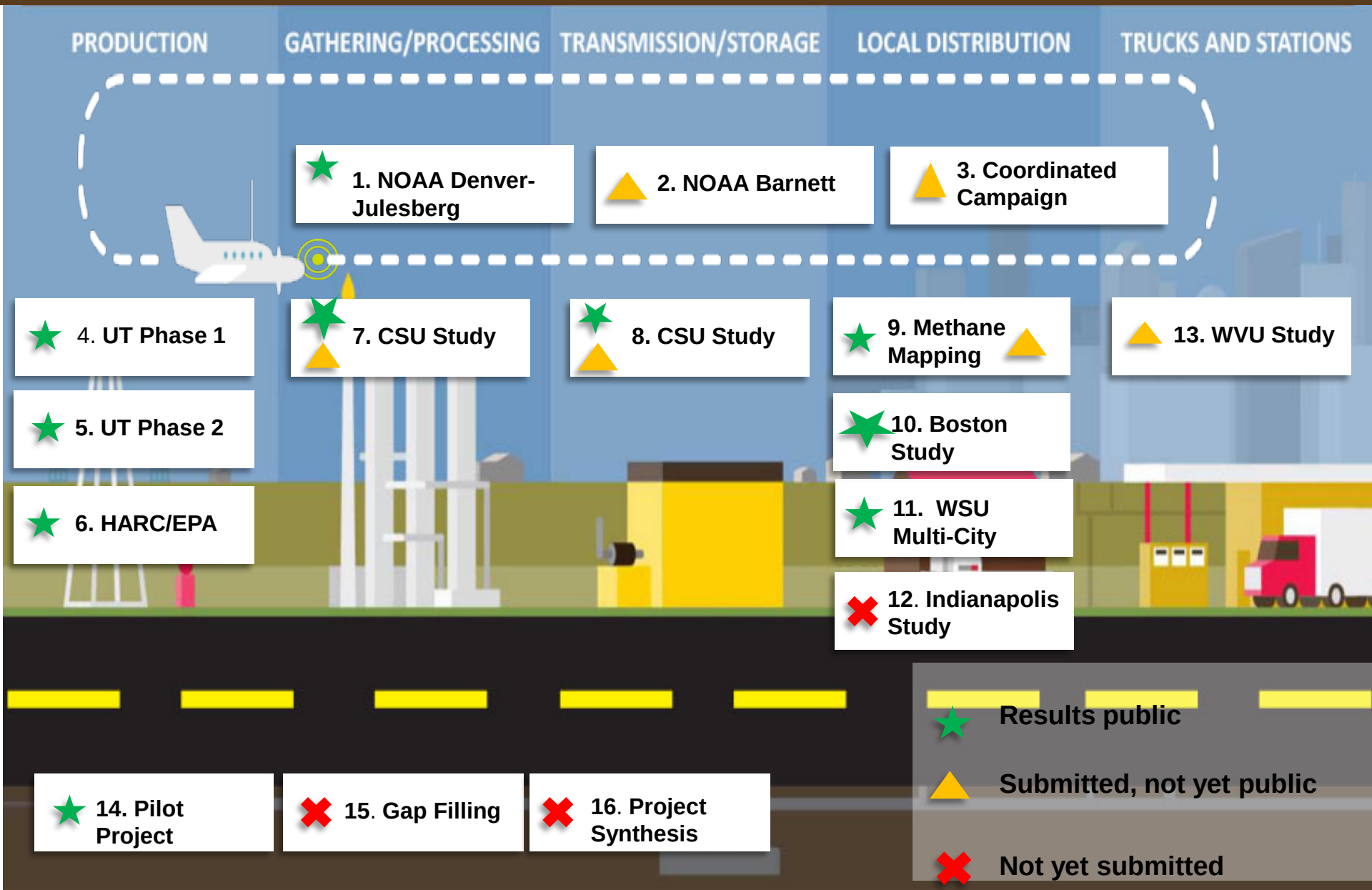
Study title indicates location, organization(s) that conducted study, and year of study

- ↑ Emissions higher than EPA
- ↓ Emissions lower than EPA
- ↔ Mixed results relative to EPA

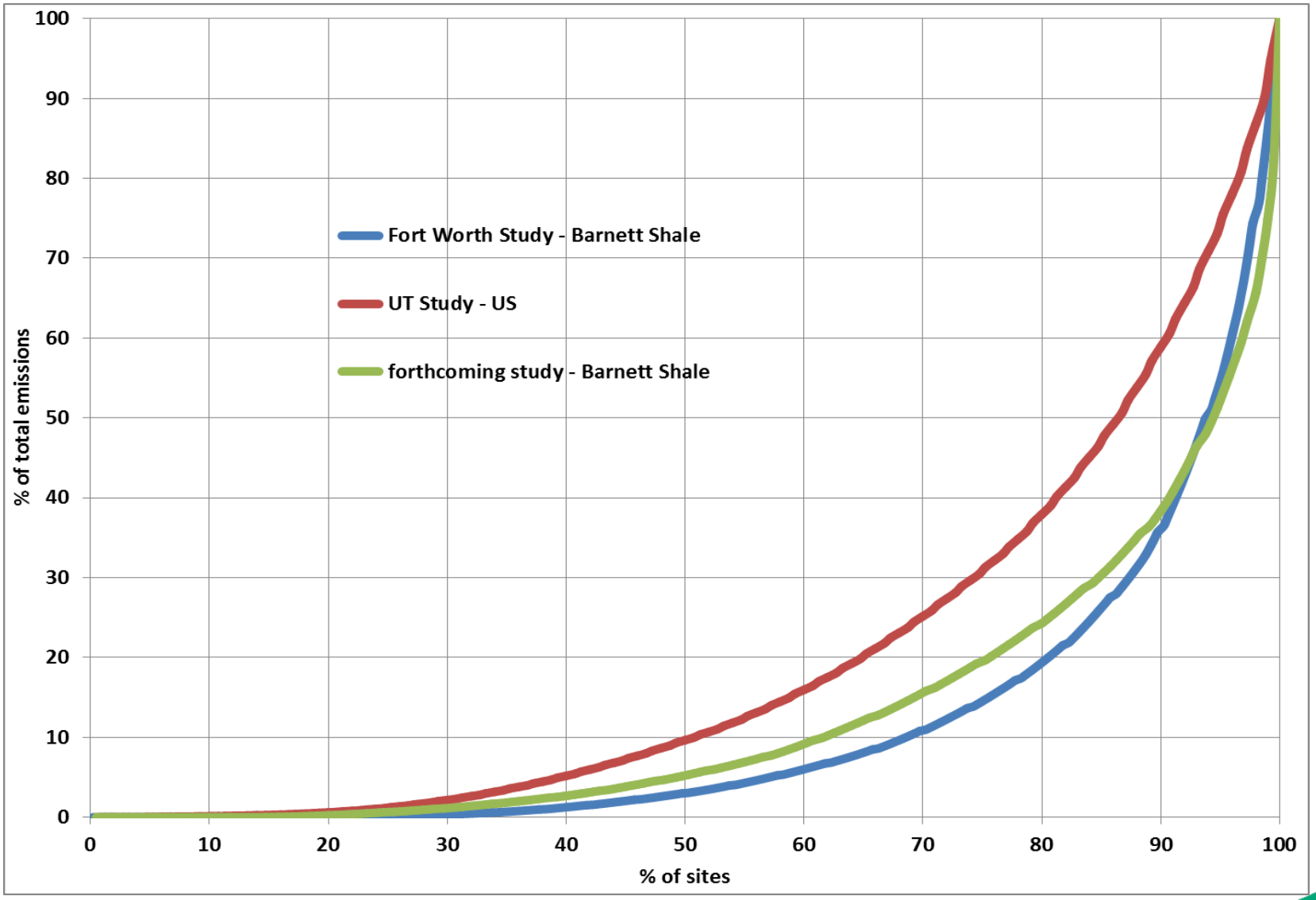
U.S. National Methane Emissions Estimates

- Miller et al. 2013
  - analysis of national atmospheric data
  - top-down 1.5X higher than EPA GHG Inventory
- Brandt et al. 2014
  - meta-analysis
  - top-down 1.25 – 1.75X higher than EPA GHG Inventory

EDF STUDIES BY U S SUPPLY CHAIN SEGMENT



“Fat Tail” of well pad emissions



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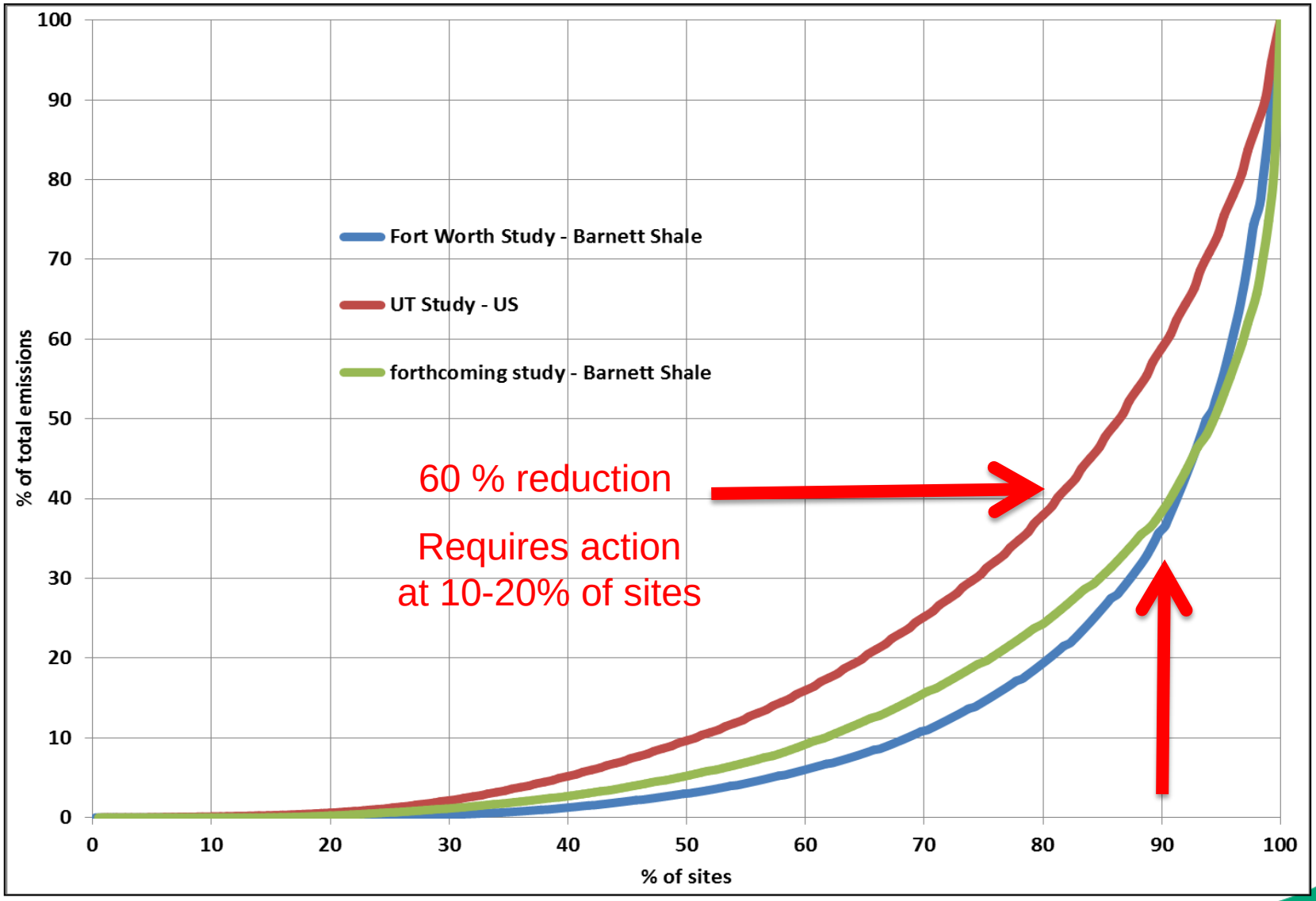
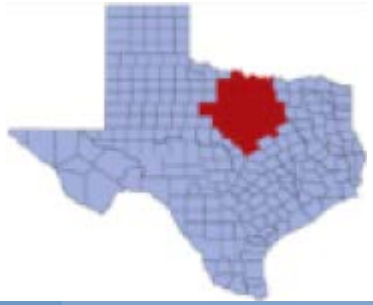


Barnett Shale

October 16 – 30, 2013



EDF COORDINATED CAMPAIGN

PRODUCTION | GATHERING/PROCESSING | TRANSMISSION/STORAGE | LOCAL DISTRIBUTION | TRUCKS AND STATIONS

NOAA/CU/Michigan Scientific Aviation/Penn State

Purdue University

Sander Geophysics

Princeton/ University of Texas - Dallas

Picarro/ Duke University

West Virginia University

Washington State University

UC Irvine/University of Cincinnati (Air Samples)

Aerodyne

University of Houston

Different approaches have pros & cons

Bottom-Up

- Accurate data at the source
- Expensive to sample many sites
- Emission sources may be missed
- Sites may not be representative
- Activity data may be incomplete

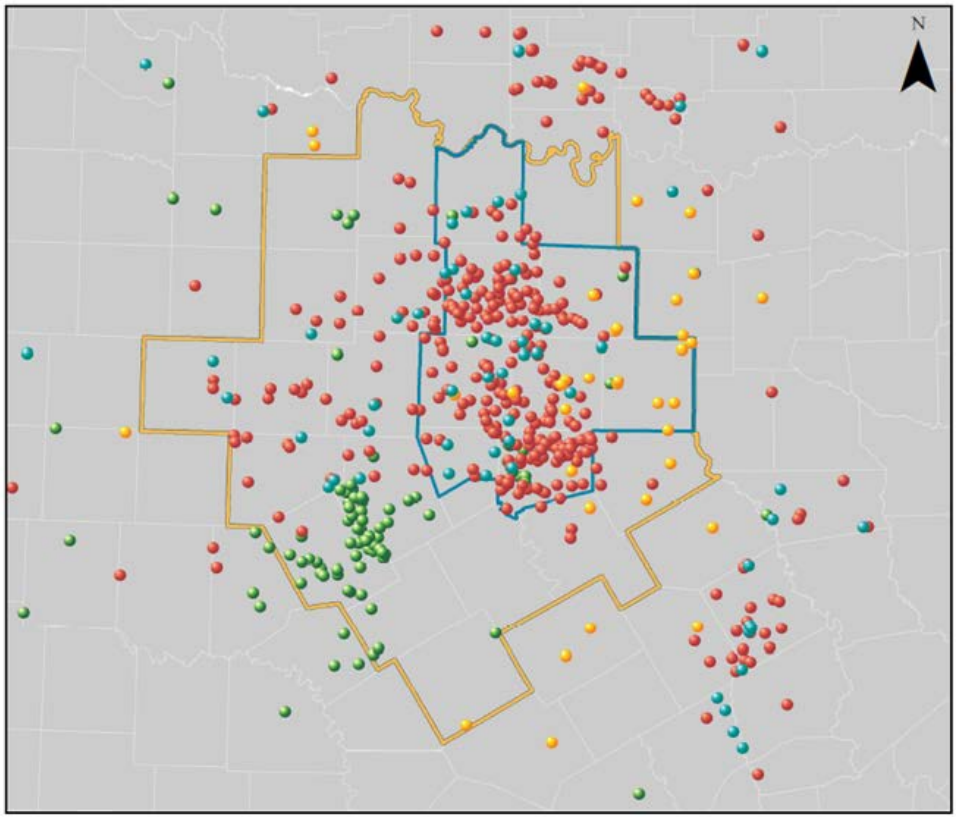
Barnett Campaign

- Bottom-up direct component measurements
  - West Virginia U. → 5 compressor stations
  - Washington State U. → 13 local distribution M&R stations
- Ground-based near-field measurements
  - Picarro → 186 well pads
  - U. Houston → 152 well pads, midstream facilities, & landfills
  - Aerodyne → 224 well pads, midstream facilities, & landfills

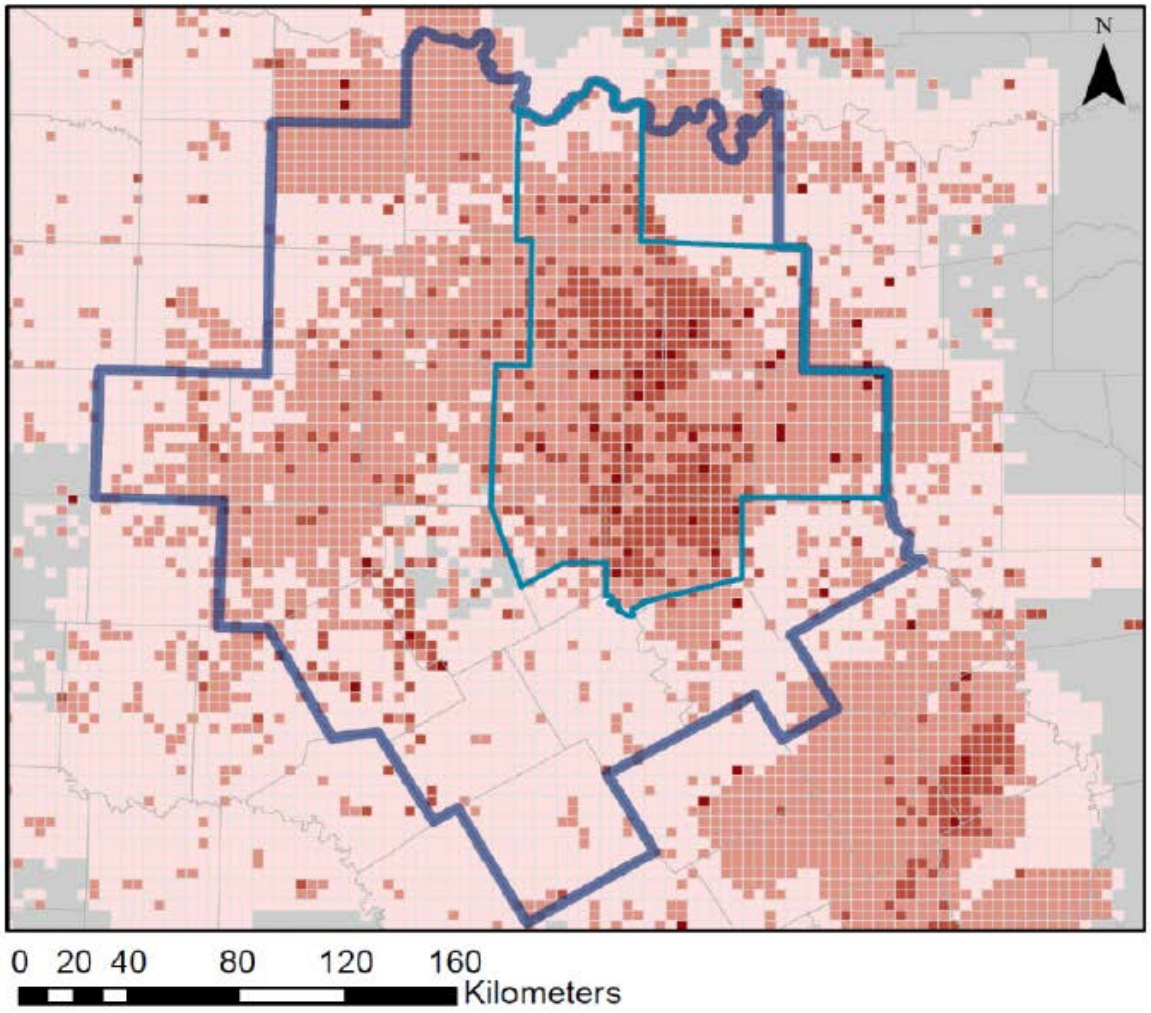
Spatially-Resolved Activity Factors

- EPA Greenhouse Gas Reporting Program
- EPA National Emissions Inventory
- TCEQ Barnett Shale Special Inventory (2009)
- TCEQ Permits
- Drillinginfo DI Desktop

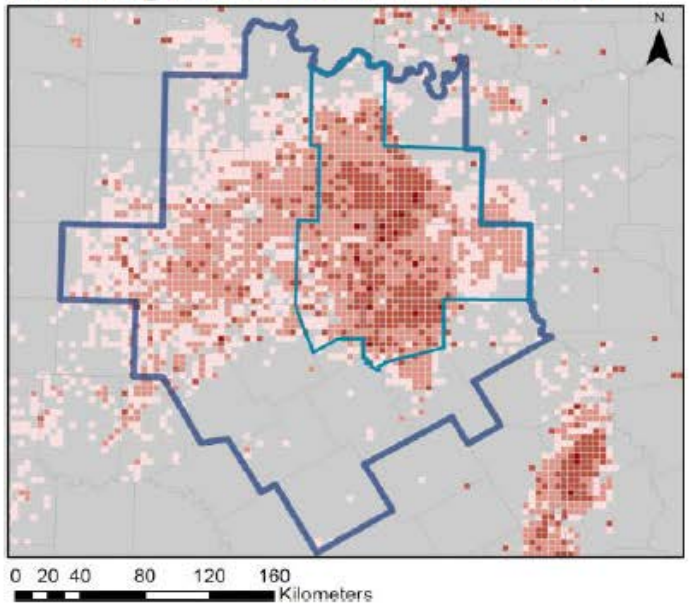
Google Earth



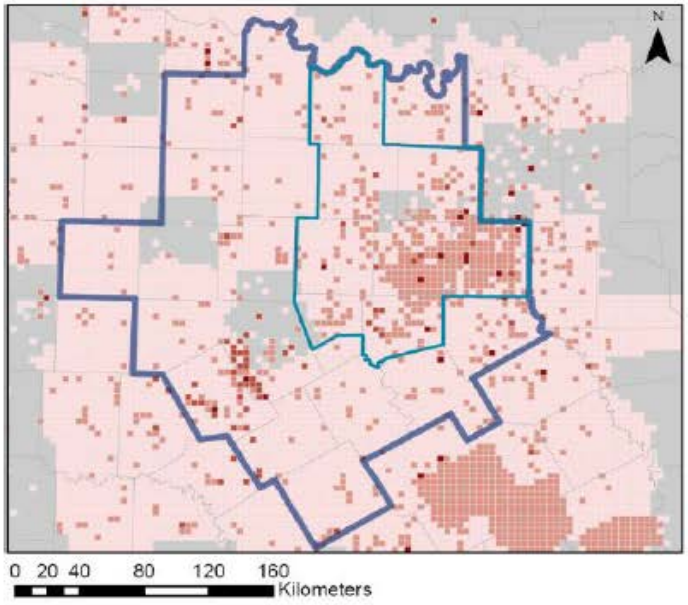
Total Methane Emissions



Thermogenic Methane Emissions



Biogenic Methane Emissions



Methane Emissions (kg/h)

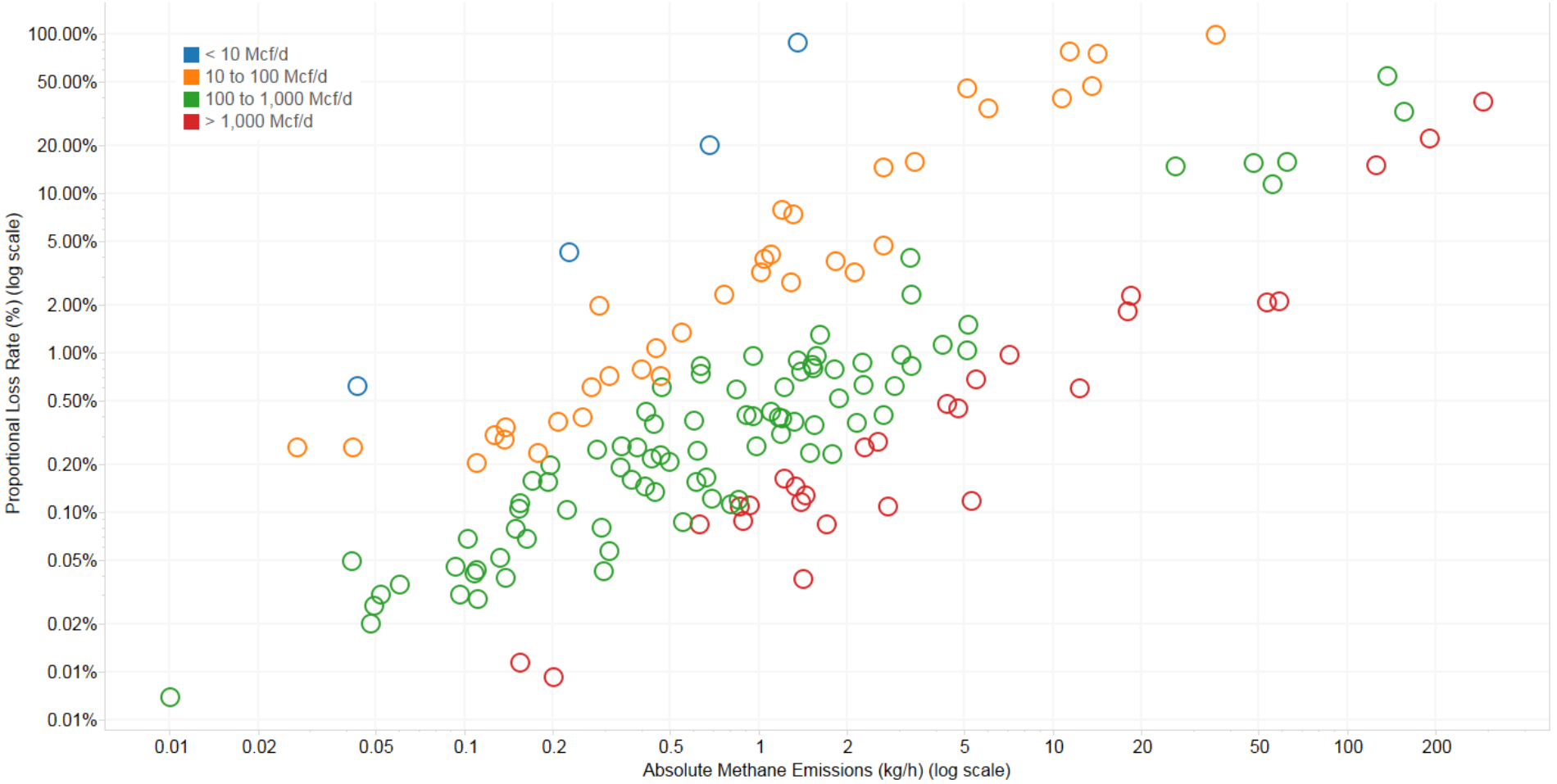
- 1 - 3.4
- 3.4 - 26.0
- 26.0 - 222
- > 222

Barnett Shale core counties

RRC Barnett Shale Boundary

-confidential: do not cite or distribute-

Proportional Methane Emissions versus Absolute Methane Emissions (log-log) Production Sites – Barnett Region



Data confidential – do not share or reproduce

Different approaches have pros & cons

Top-Down

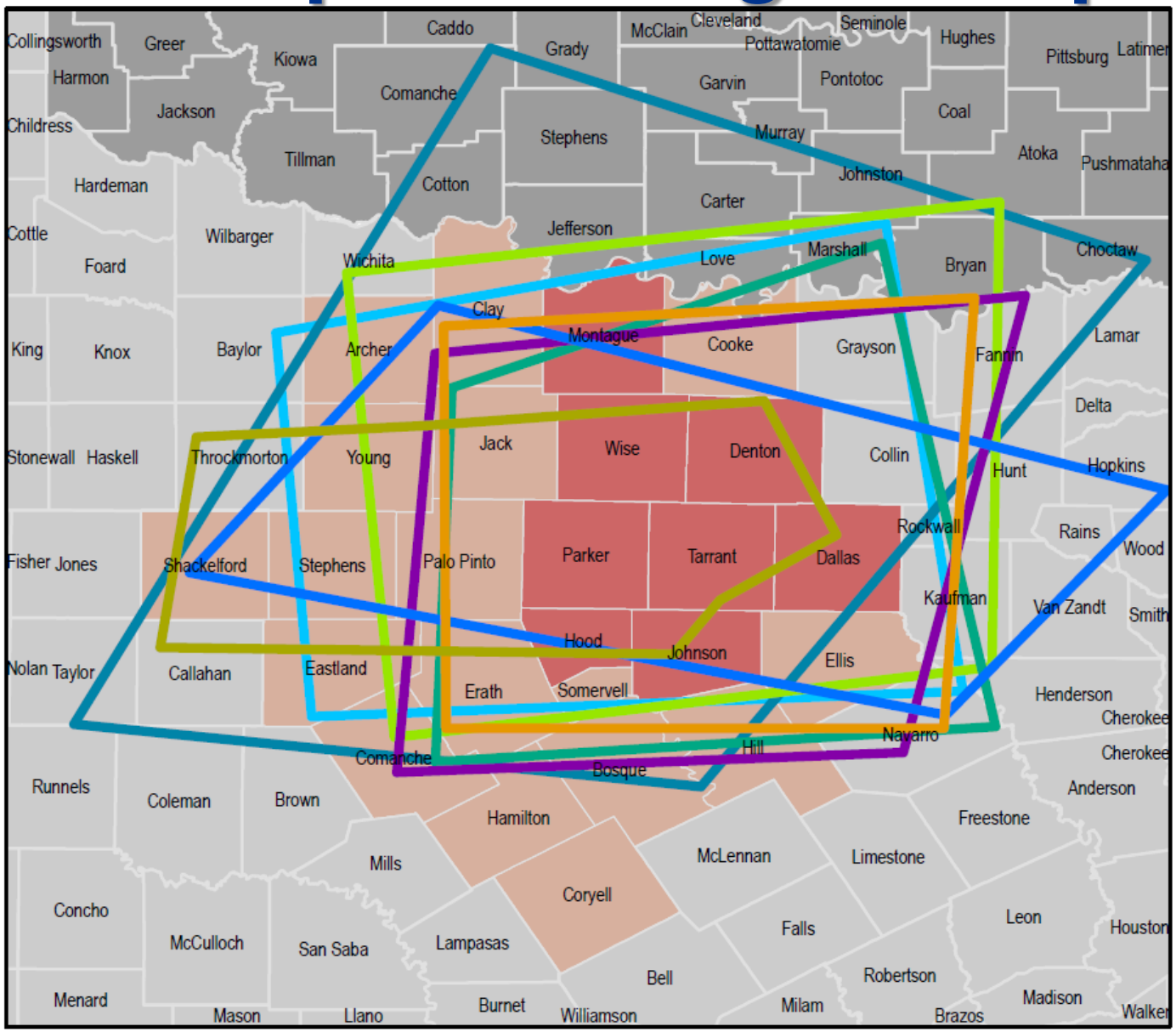
- Total emissions from large area
- Difficult to distinguish sources
- Typically from short time period

photo credit: U. of Texas

Barnett Campaign

- Aircraft-based near-field measurements
  - Purdue → 8 midstream facilities & landfills
  - Princeton/UT-Dallas (remote-control model aircraft) → repeat measurements of one compressor station
  - Sander Geophysics/Shell Global Solutions → locations & emission rate of sources in survey areas by Markov Chain Monte Carlo analysis
- Aircraft-based top-down regional measurements
  - NOAA/CU/Scientific Aviation/U. Michigan/Penn State → mass balance estimates on 8 days

Top-down flight footprints



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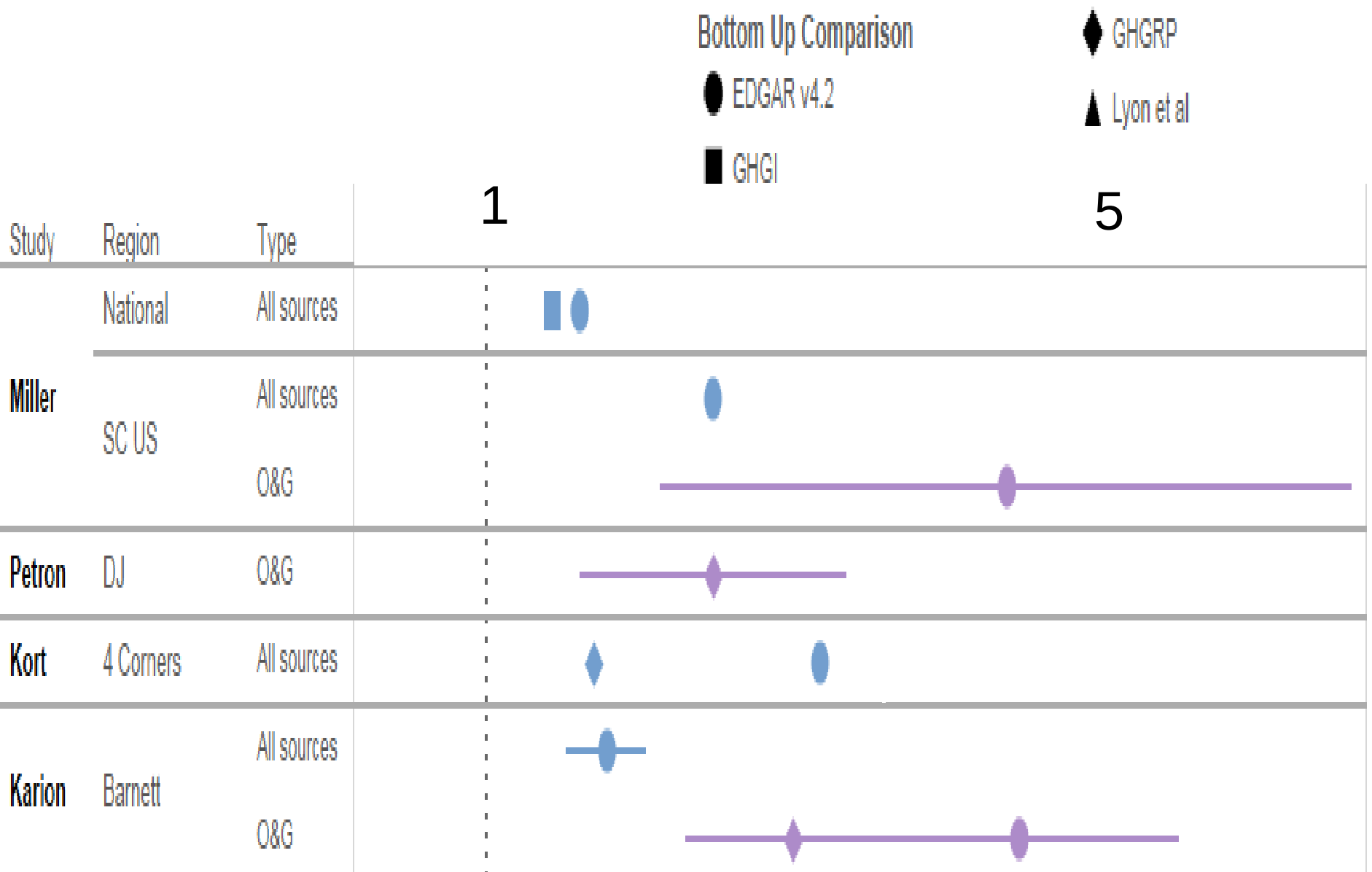
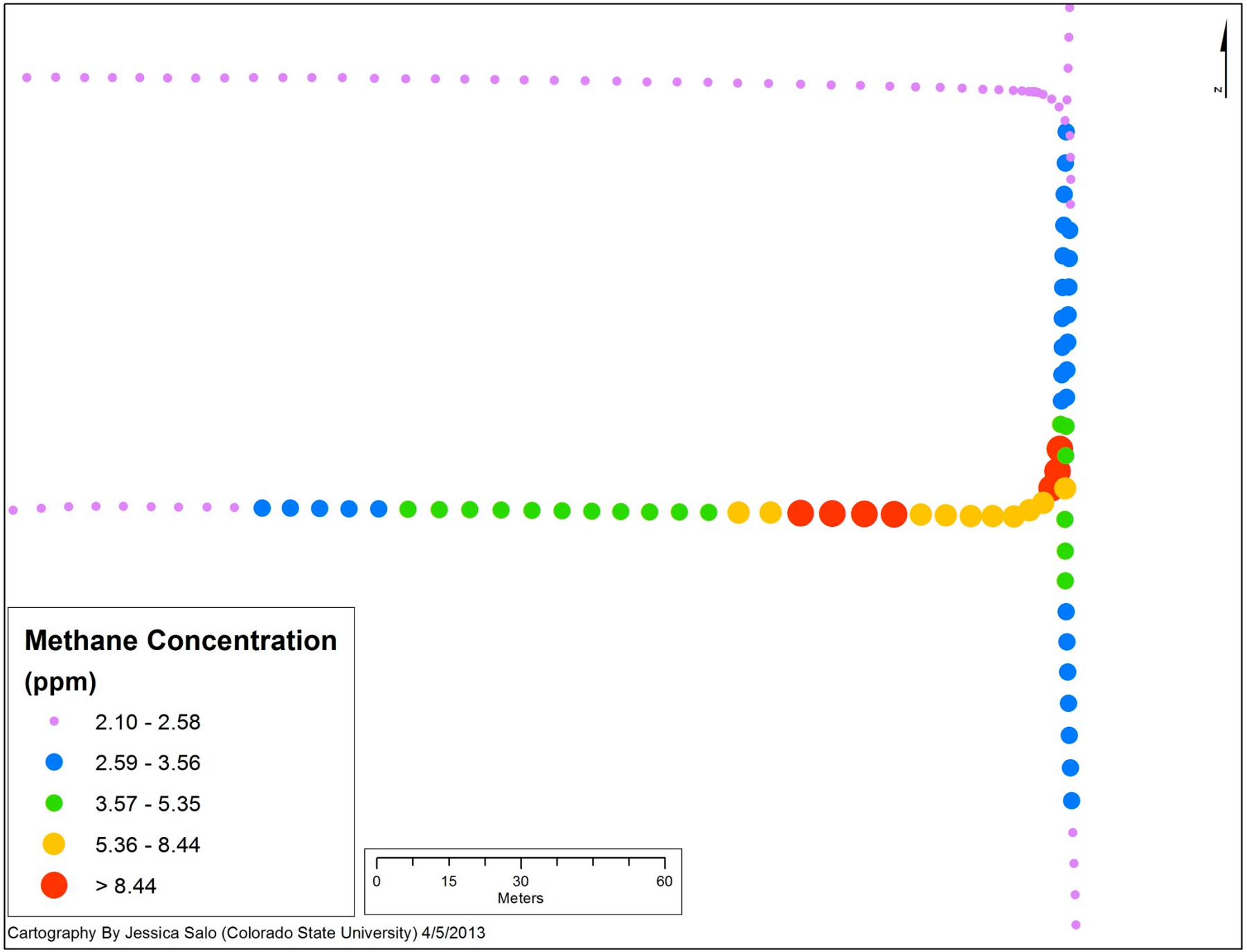
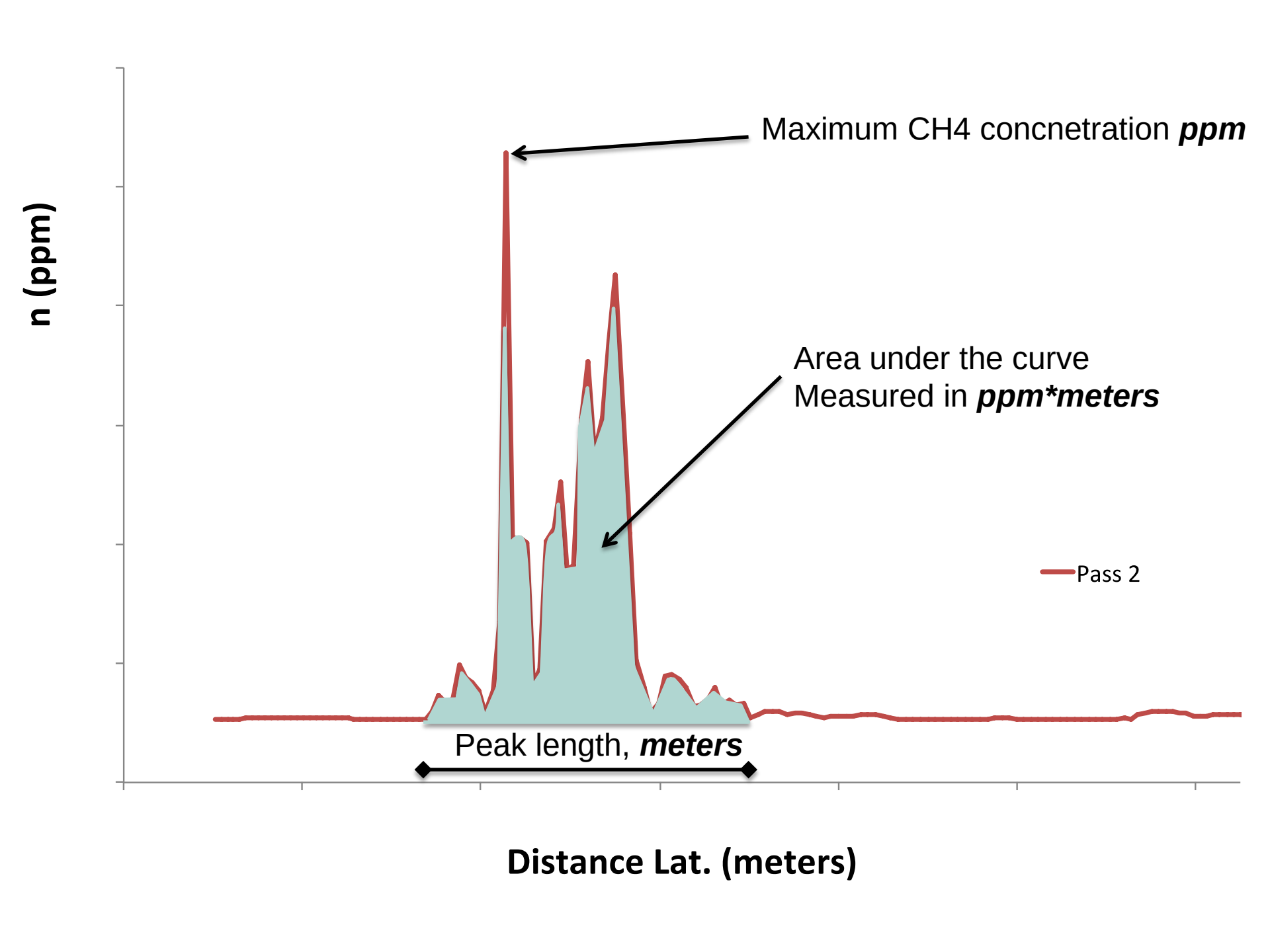
Reconciling top down and Bottom up methane emissions




Google maps
Street View
google.com/streetview



Cartography By Jessica Salo (Colorado State University) 4/5/2013


n (ppm)
Maximum CH4 concnetration ppm
Area under the curve
Measured in ppm*meters
Pass 2
Peak length, meters
Distance Lat. (meters)


YOUNG
Google maps
Street View
6KKS295

Leak rate estimation

- We conducted controlled release experiments
  - Varying methane release rate between 0.5 and 40 liters/minute (=1 to 84 cubic feet/hour).
  - Drove vehicle through plume to develop a statistical relationship between release rate and observed methane patterns
- Leak rate estimate not precise, but can tell Low (0-6 L/min), Medium (6-40 L/min) High (>40 L/min)

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

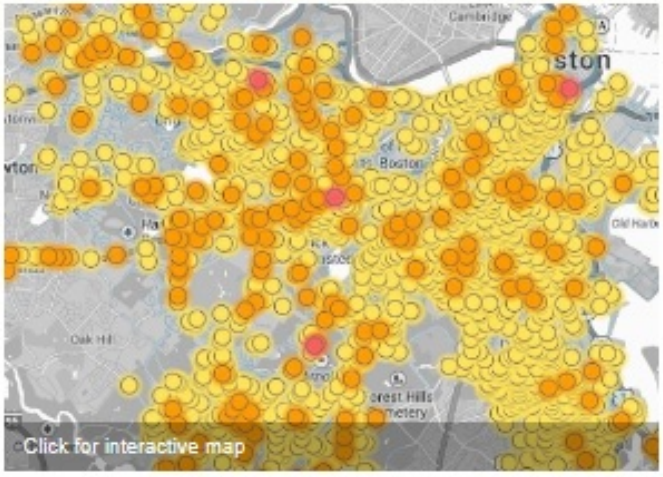
Ecosystems

Natural gas: Local leaks impact global climate

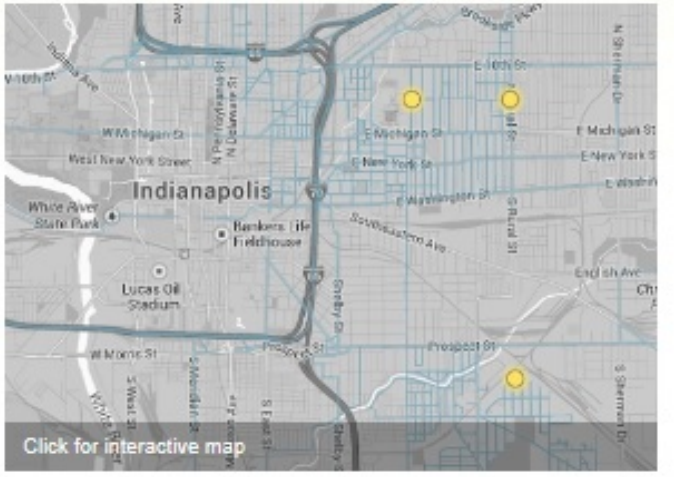
EDF and Google Earth Outreach use new approach to pinpoint climate pollution

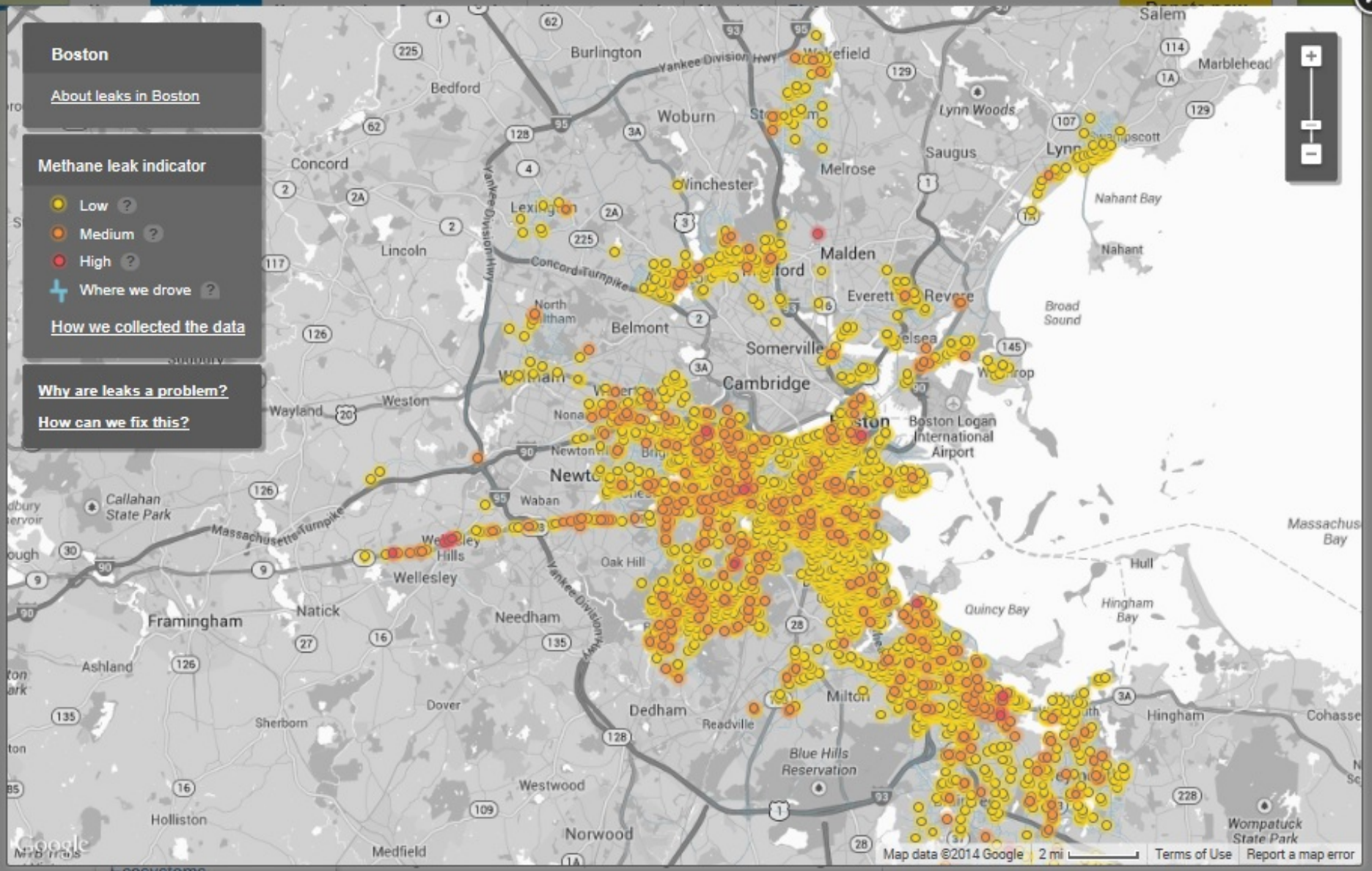
Natural gas heats our homes and cooks our dinner. But when natural gas—mostly methane—leaks into the air, it's a big problem for the climate. So EDF and Google Earth Outreach teamed up to build a faster, cheaper way to find and assess leaks under our streets and sidewalks. We tested it as part of a pilot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

Boston: Older pipes, more leaks



Indianapolis: Newer pipes, fewer leaks




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?
Salem
Marblehead
Burlington
Bedford
Woburn
Melrose
Saugus
Lynn
Lynn Woods
Nahant Bay
Nahant
Concord
Lincoln
Malden
Everett
Revere
Broad Sound
Belmont
Somerville
Cambridge
Boston Logan International Airport
Weston
Wayland
Newton
Waban
Callahan State Park
Massachusetts Turnpike
Wellesley Hills
Wellesley
Oak Hill
Framingham
Natick
Needham
Hull
Quincy Bay
Hingham Bay
Ashland
Dover
Sherborn
Dedham
Readville
Milton
Hingham
Blue Hills Reservation
Westwood
Holliston
Norwood
Medfield
Wompatuck State Park
Google
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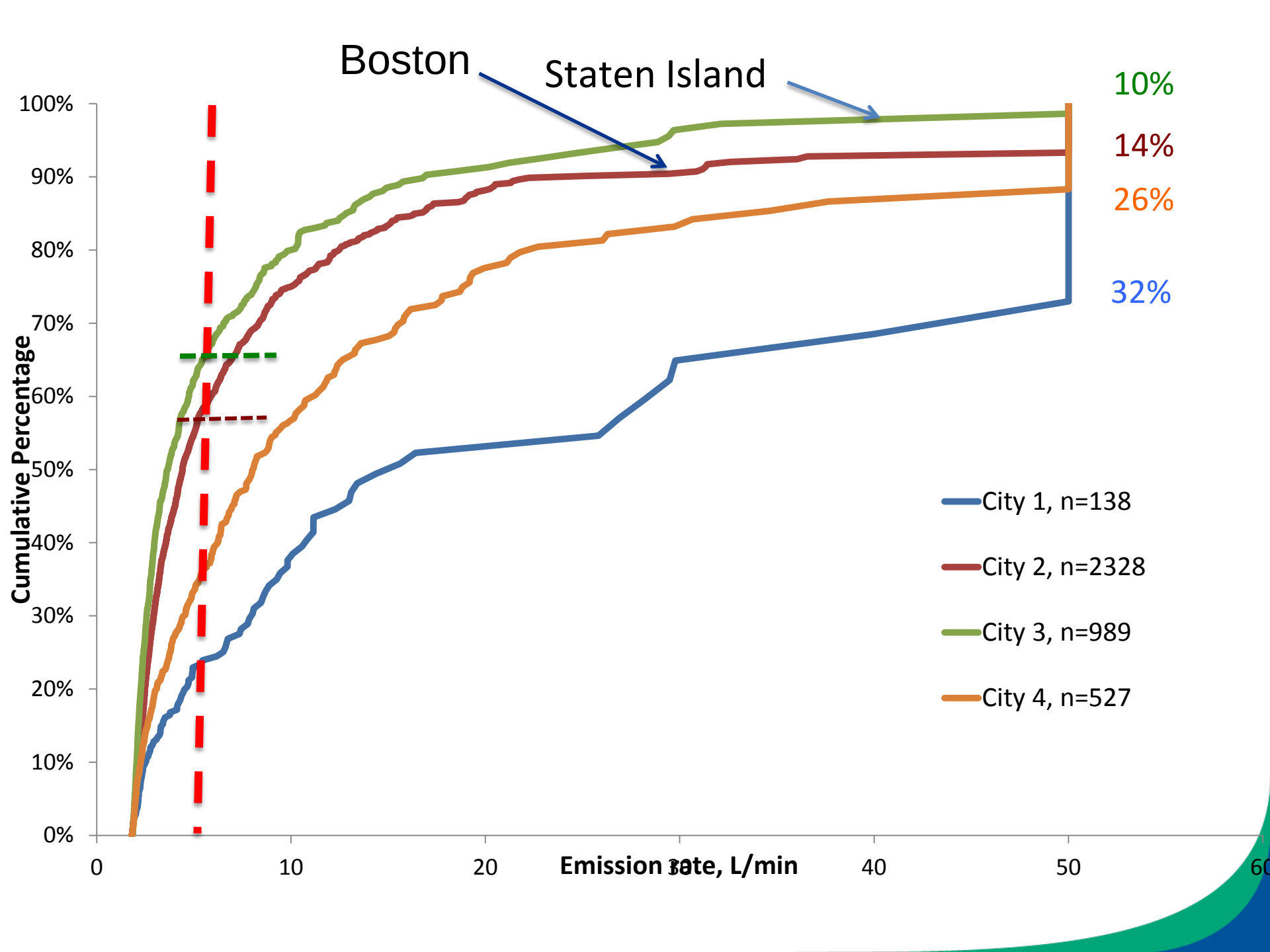
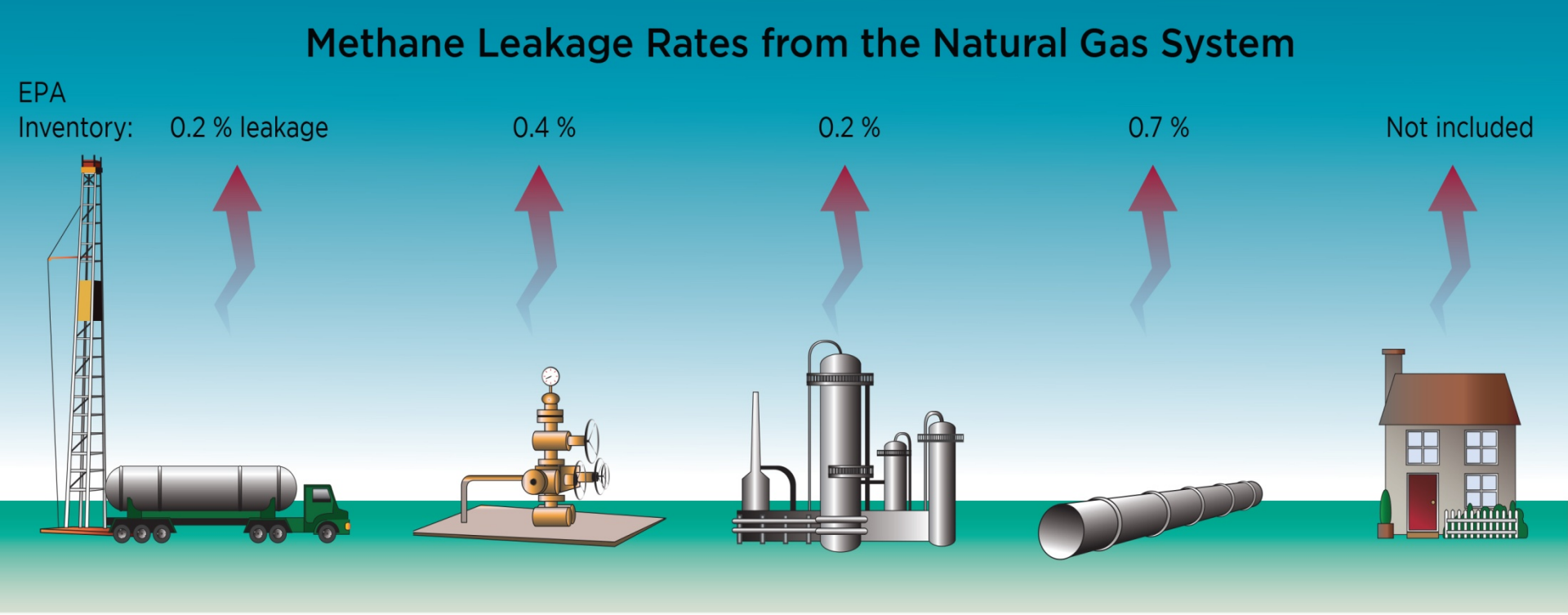
Report a map error
Ecosystems


Boston
Staten Island
10%
14%
26%
32%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cumulative Percentage
0
10
20
30
40
50
60
Emission rate, L/min
City 1, n=138
City 2, n=2328
City 3, n=989
City 4, n=527

Methane Leakage Rates from the Natural Gas System



Drilling and fracturing — **Production** — **Processing** — **Transportation and distribution** — **End use**

Total NG leakage - EPA: 1.5 %

Evidence from other Studies

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Methane Detectors Challenge – Innovation^2

Define user needs, pilot technology

BG GROUP

HESS

swn Southwestern Energy®

Apache

Shell

Anadarko Petroleum Corporation

noble energy

Convene and catalyze

EDF ENVIRONMENTAL DEFENSE FUND™ Finding the ways that work

Innovate!

- Colorado start-up (Quanta3)
- Fortune 500 company (Honeywell w/SenseAir)
- Chinese laser company (Dalian Actech)
- Academic (U of Colorado w/NDP)

Advise

SwRI

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

HARVARD UNIVERSITY

CLEANAIR TASK FORCE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

…and more…

Thank You

shamburg@edf.org