Air Impacts of Gas Shale Extraction and Distribution

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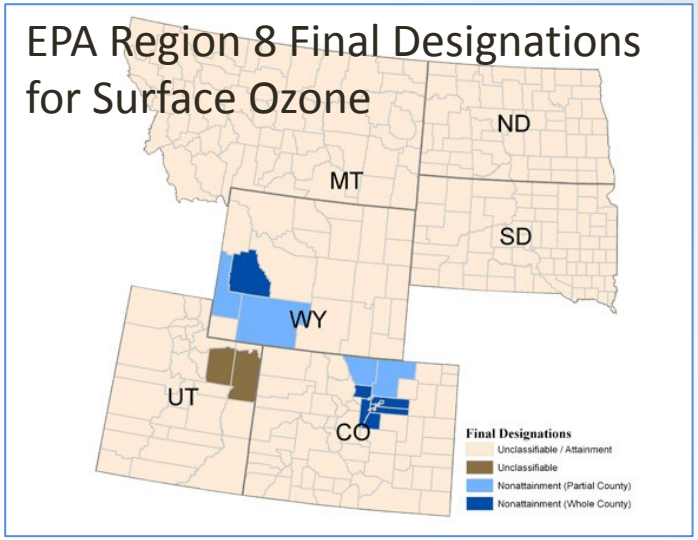
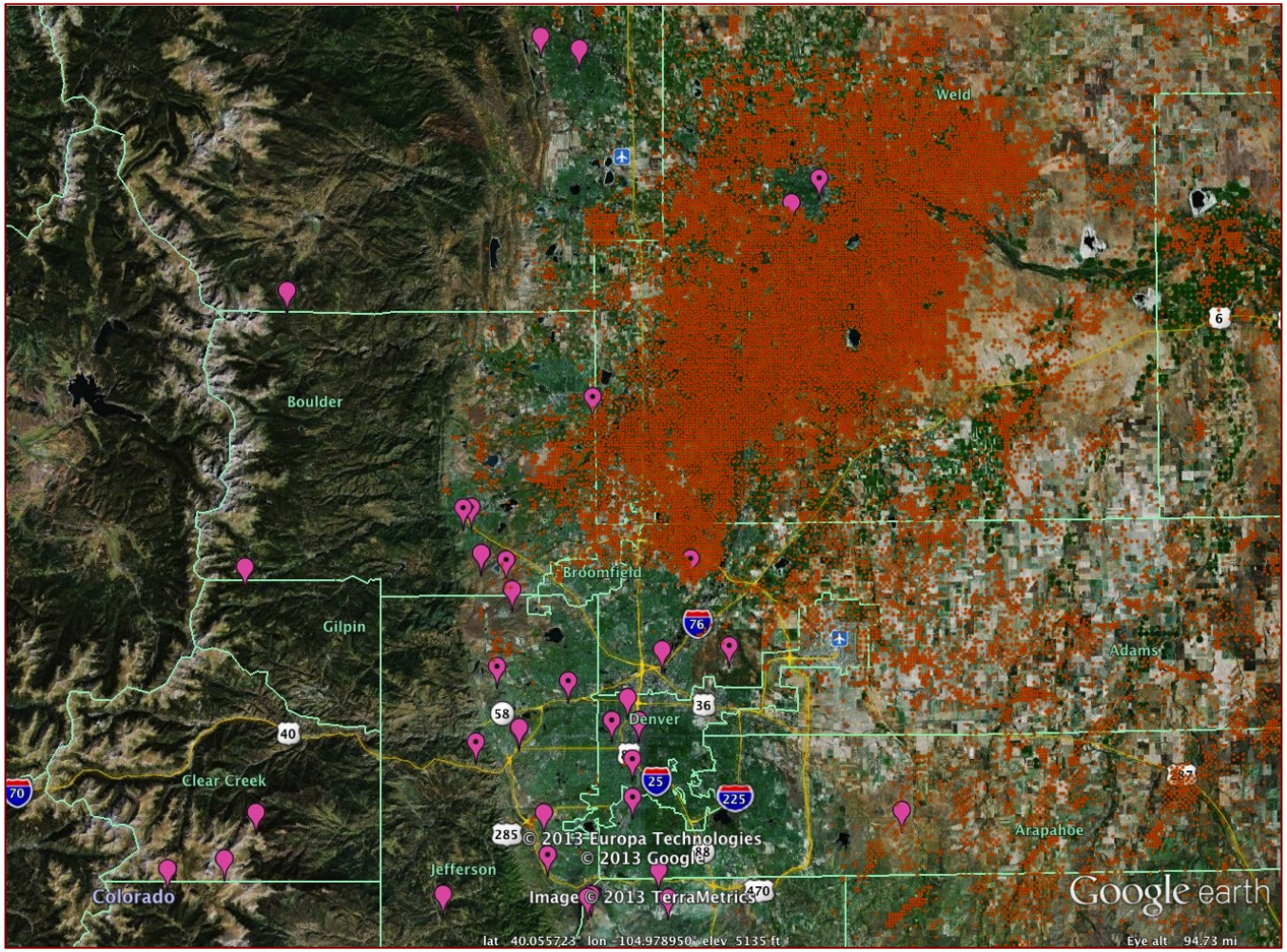
Air Pollutants



- **What is regulated?**
  - At the National Level (US EPA):
    - Ozone
    - Air Toxics
    - Full implementation by January 2015: EPA NSPS (VOCs)
  - At the State Level:
    - Ozone precursors emissions *IF* non attainment for ozone
- **GHGs are not regulated** but there are new reporting requirements to EPA for large upstream and midstream sources (GHG Reporting Program).

Where do we monitor?

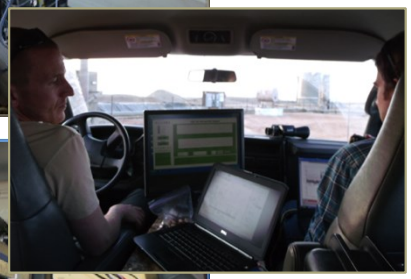
Colorado Front Range

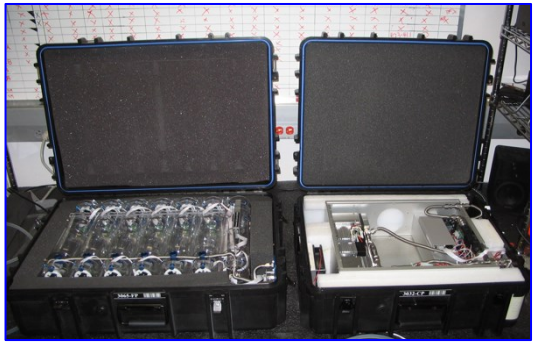


Orange dots: active oil and gas wells

Pink bubbles: "Official" Ozone monitors

How do we measure or sample the air composition?





Tower, aircraft and van in-situ and canister sampling

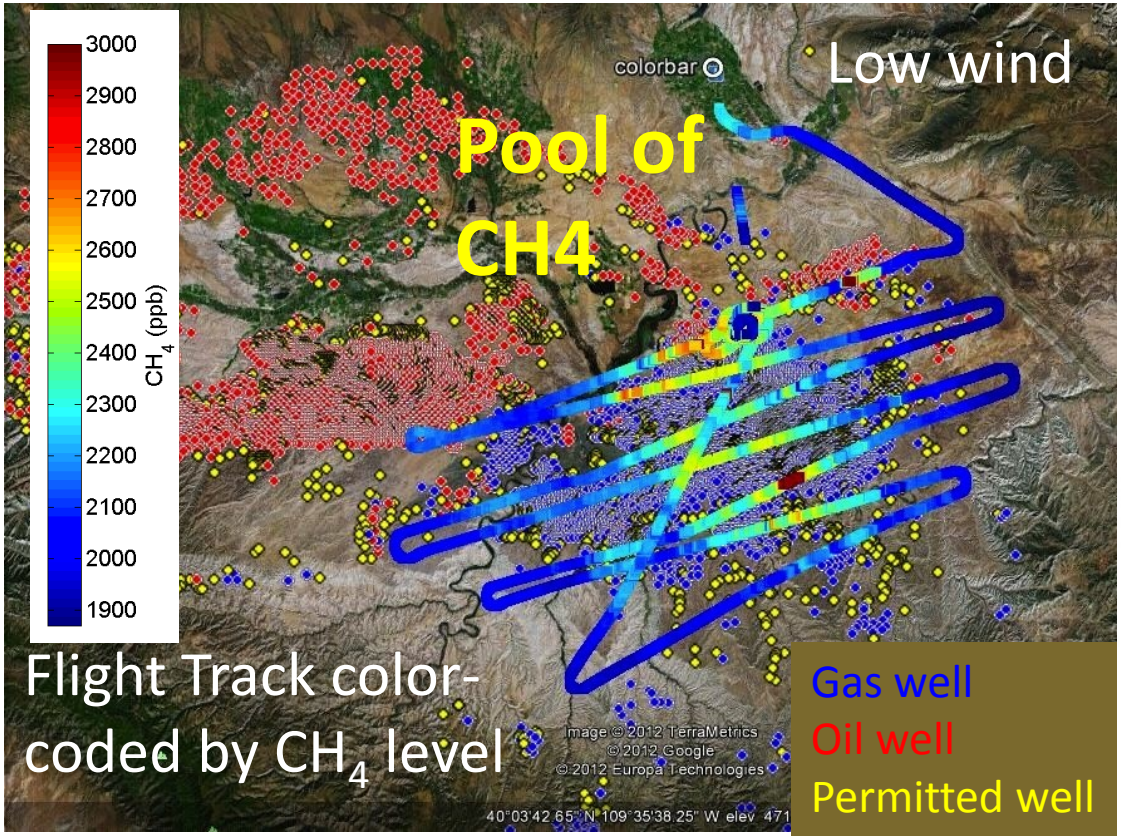
CCGG MAGICC

CO_2 CH_4 N_2O SF_6 CO H_2

HATS GC/MS
43 species

Uinta Basin - February 2012

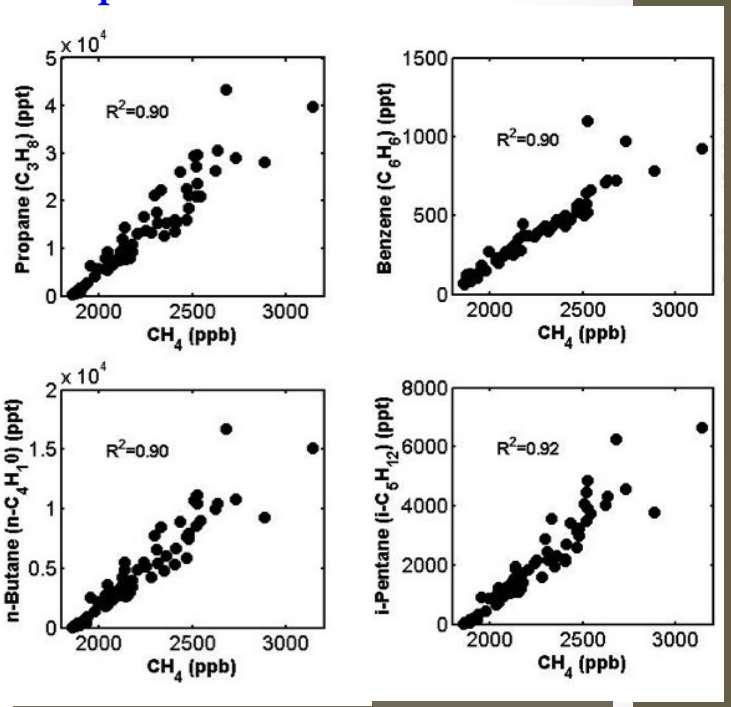
Uintah Basin NOAA GMD Flight, February 7, 2012



Oil and Gas production is the main activity in the Uintah Basin.

Multi-laboratory campaign coordinated by EPA region 8 and State of Utah

Uintah Basin - February 2012 NOAA GMD Aircraft discrete samples data

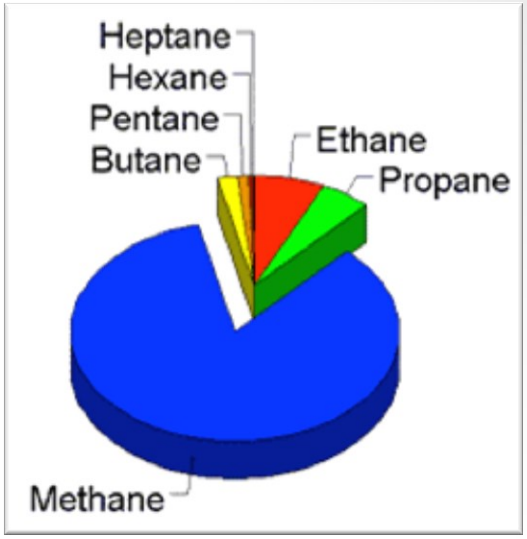


Strong correlation between methane, the light alkanes and benzene in samples collected in the Uintah Basin in 2012.

2012 report :http://www.deq.utah.gov/locations/uintahbasin/docs/2013/UBOSWinter2013studyplan11202.pdf

Air Pollutants

- Greenhouse gases emissions (CH_4, CO_2)
- Surface ozone precursors emissions
- Air Toxics (BTEX, H2S,…)
- PM, silica



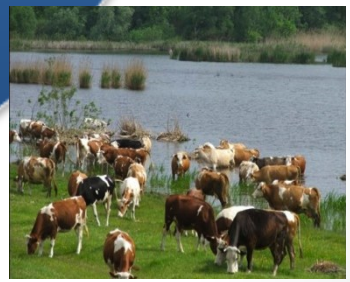
Additives at an injection well site, Utah

Additives used for normal operations, maintenance, completion:

- Acids
- Methanol
- Biocides
- Solvents

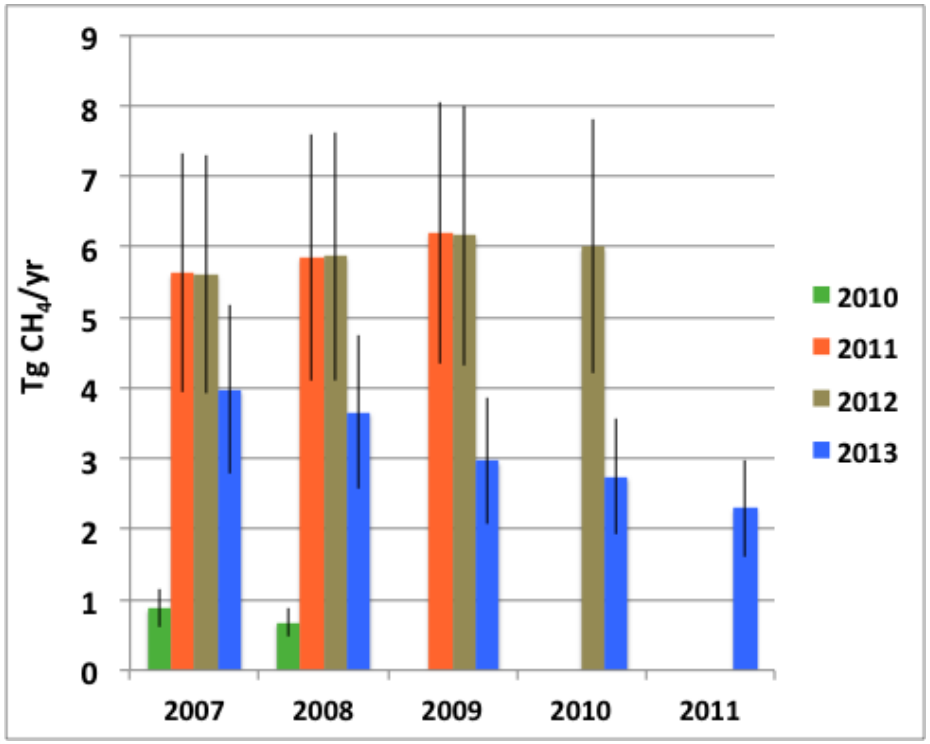
2011 CH_4 emission estimates in the US

Oil & Gas Systems
30% Total US
Methane Source



How well do we know emissions?

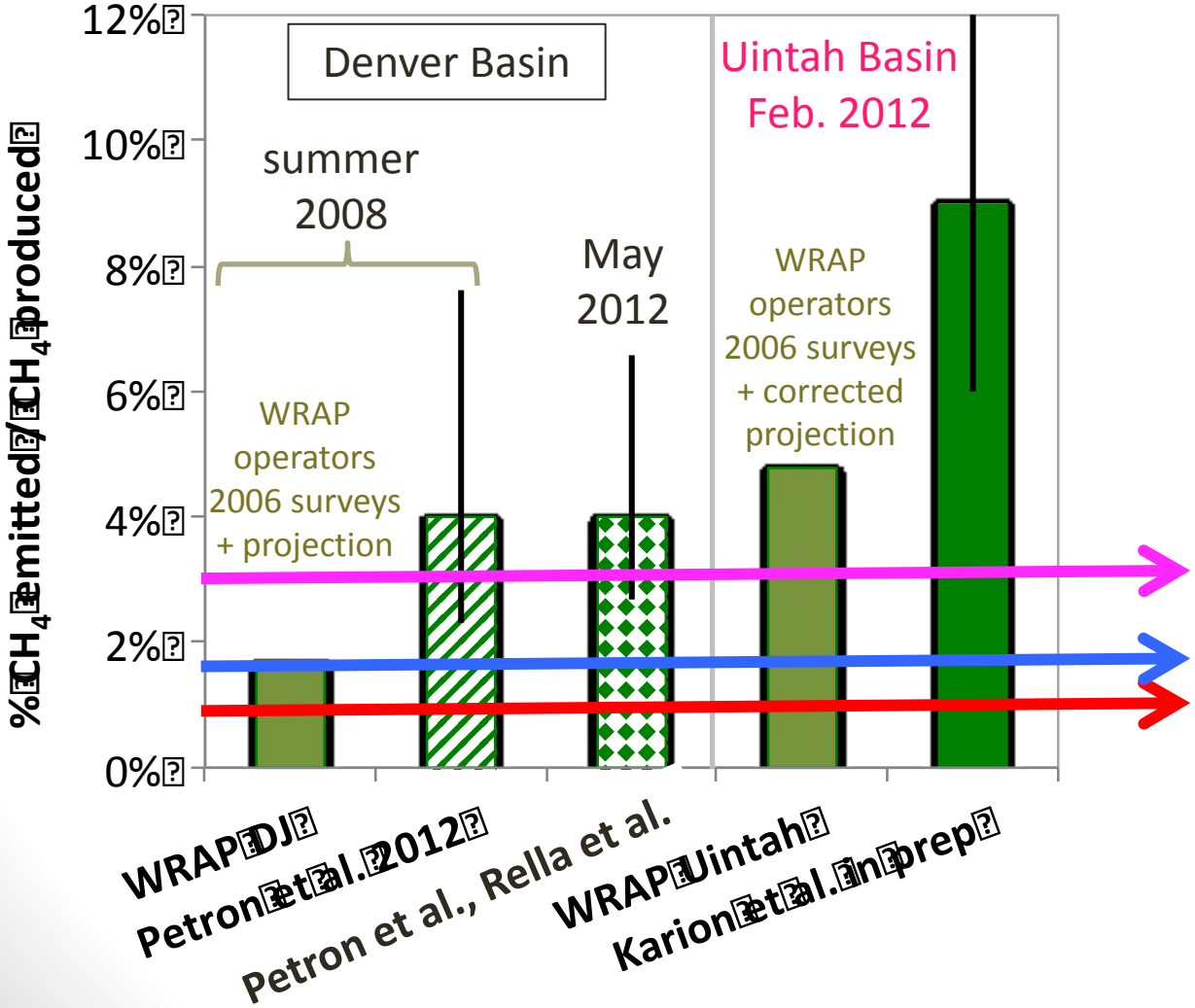
EPA national GHG inventory



- Exploration &Production = Largest source of CH_4 and VOCs for natural gas systems
- Factor of 2 to 8 changes in recent years (related to changes in methodology and assumptions)
- Reported uncertainty for all these different estimates: only 20%

Regional top-down studies indicate that bottom-up estimates are too low…
National-level emission estimate is going to go down in next GHG inventory…
What are we missing?

Three Regional Studies with atmospheric constraints on regional CH_4 flux (field production and processing)



3% for net climate benefit compared to coal for power generation Alvarez et al., 2012

2013 EPA NG systems TOTAL CH_4 loss 1.9%

2013 EPA Gas Production and Processing CH_4 loss 1.0%

Priorities

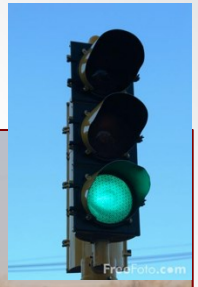
- Quantify ACTUAL emissions, especially FUGITIVES
- Estimate ACTUAL emission reduction from BMP
- EFFECTIVE, SCALABLE Leak Detection Program
- Cooperation between many stakeholders incl. scientists to test and improve measurement and detection protocols

- Deploy new monitoring and detection techniques
- Go beyond controversy to identify what works and what does not

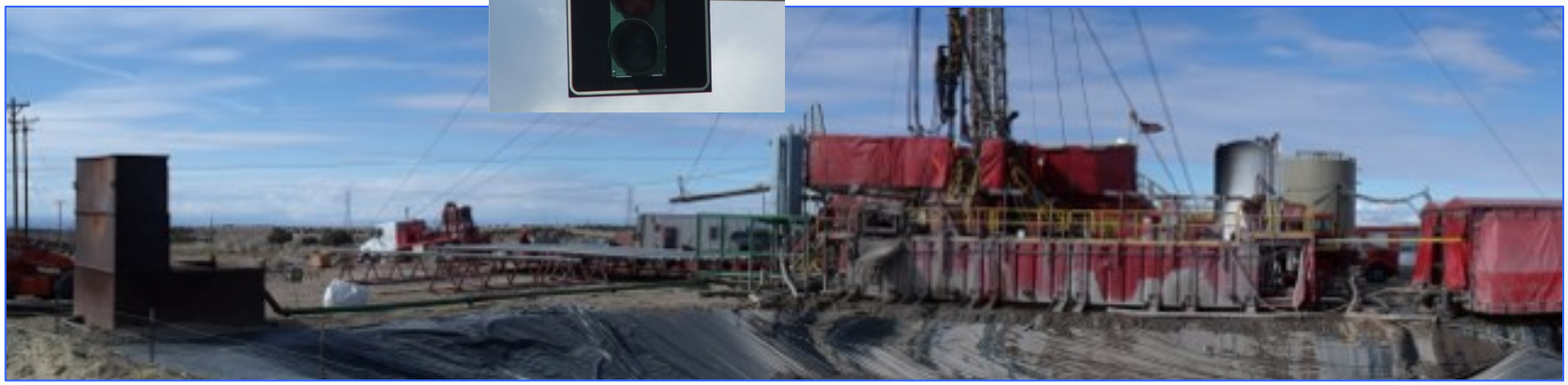
Completion from red to green

Operations, practices, gas composition, regulation do vary from one Basin to another

Flowback, Colorado, 2013
Legislation since 2009



Flowback, Utah, 2012
Indian & BLM Land



Dish, TX

Slides from Eric Crosson, Picarro 2013 work

Gas covers entire neighborhood one mile down wind of leaking natural gas facilities in Dish, TX

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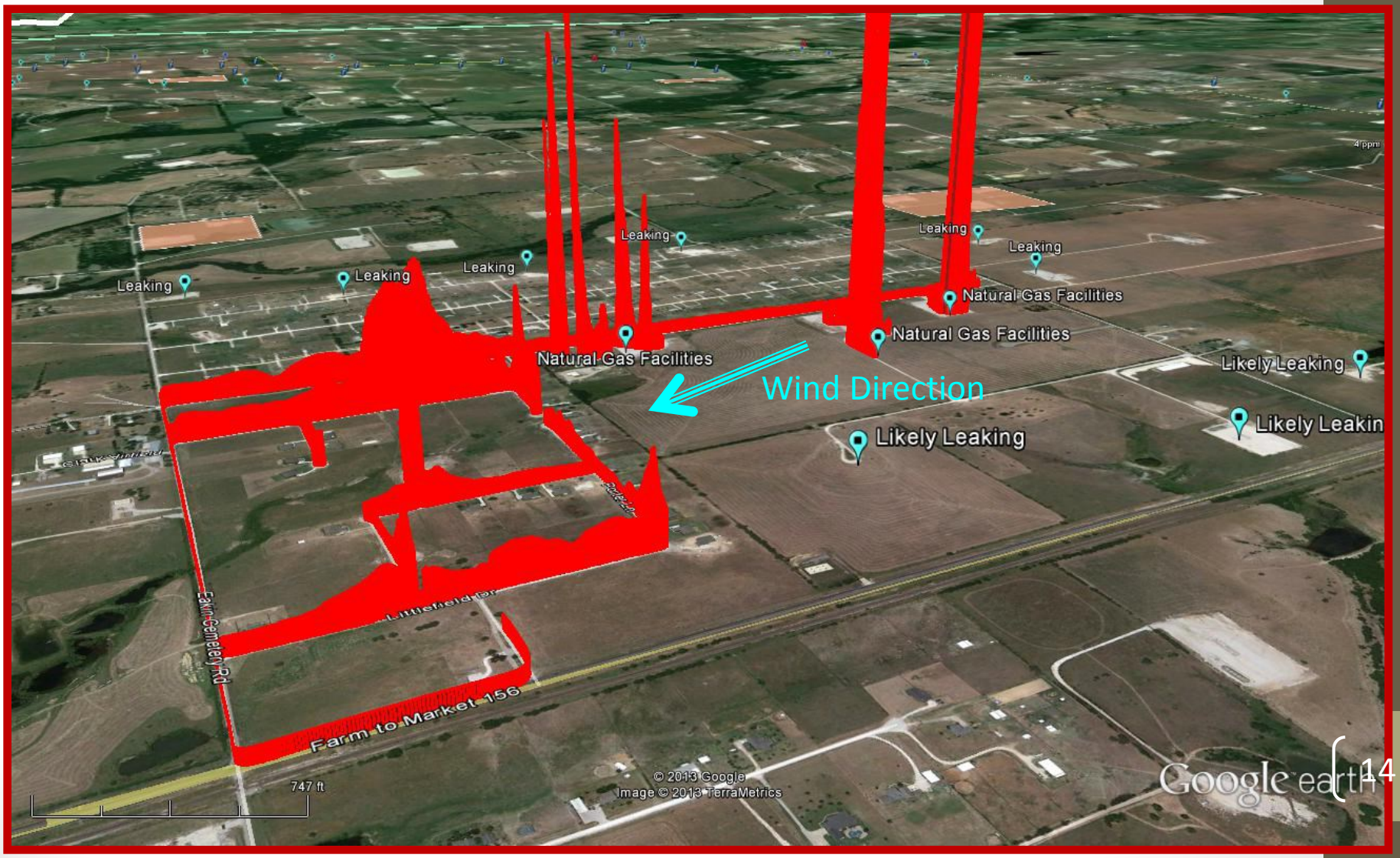

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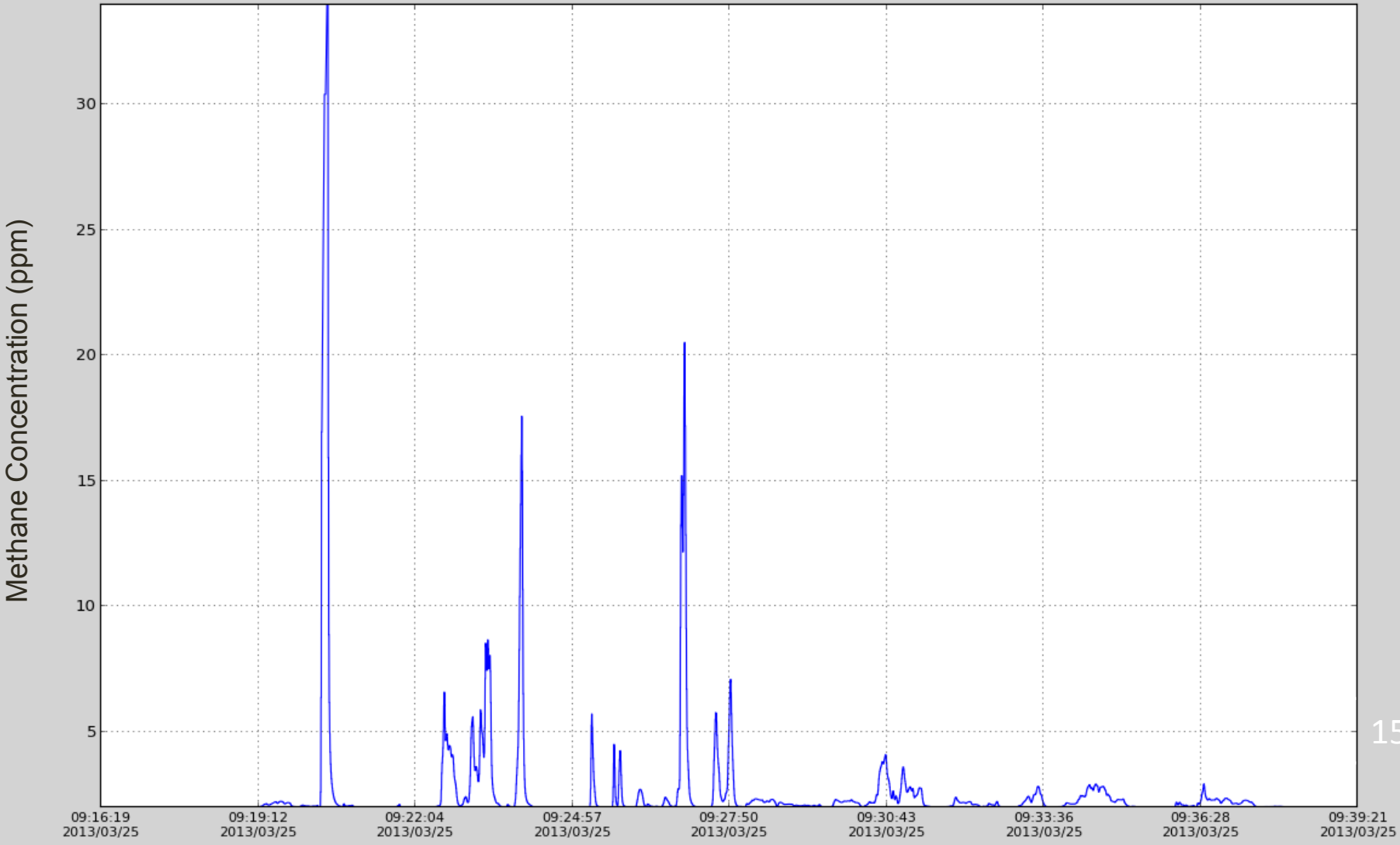
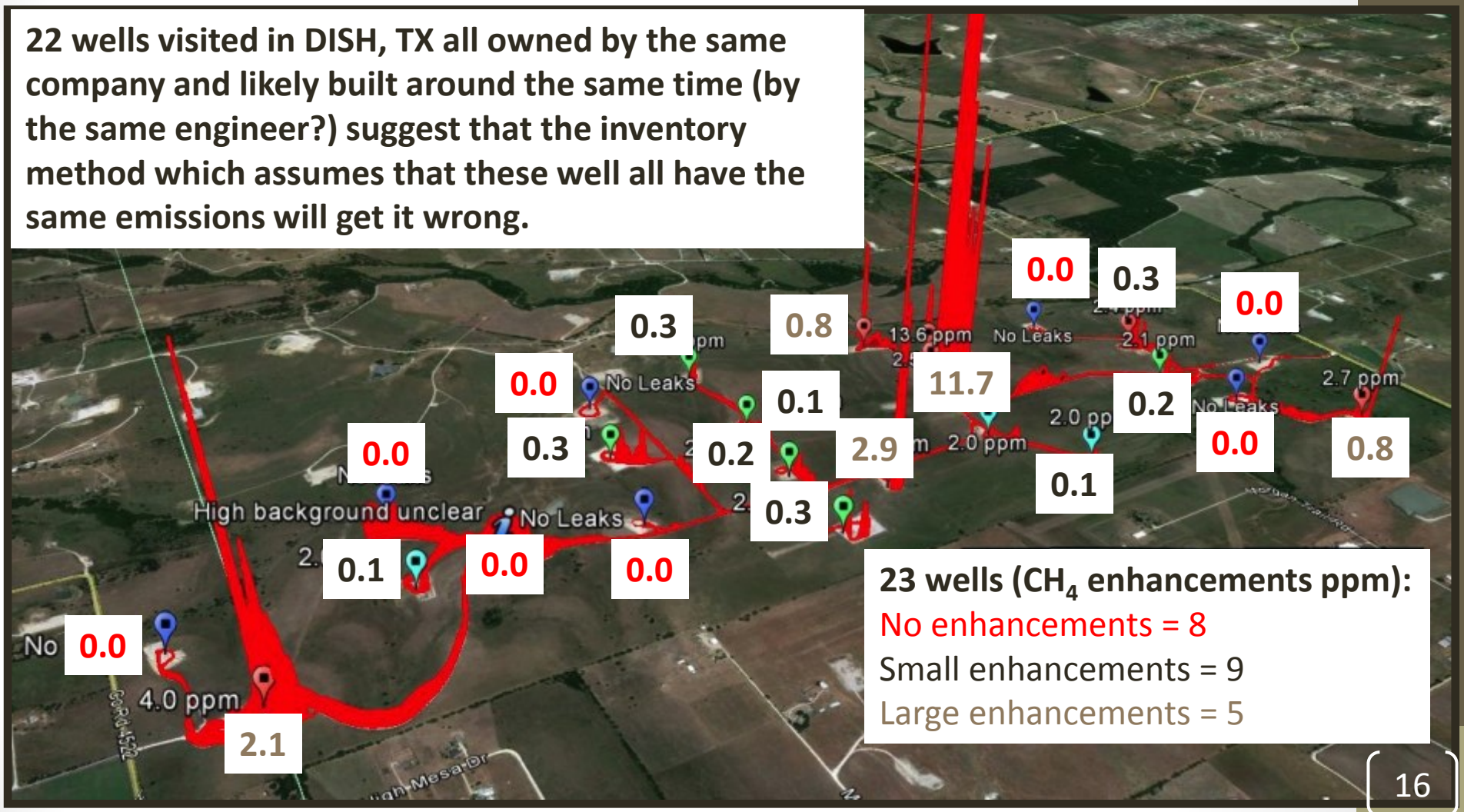
Gas covers entire neighborhood one mile down wind of leaking natural gas facilities in Dish, TX



Can inventories work?

22 wells visited in DISH, TX all owned by the same company and likely built around the same time (by the same engineer?) suggest that the inventory method which assumes that these well all have the same emissions will get it wrong.



23 wells (CH_4 enhancements ppm):
No enhancements = 8
Small enhancements = 9
Large enhancements = 5

[Activity data] X [emissions factor]

Data provided by Eric Crosson, Picarro

How do we know what we know?

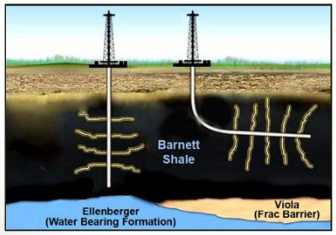
- **Emission Inventories** = Modeled estimates based on:
  - Activity data
  - > 10s-100 emission factors EF (for ex: EPA/GRI study 1996)

  ➔ Most EF are extrapolated to next 20 years and the entire nation
- **Self reported (industry) data** (for ex. API/ANGA 2012)
  - Activity data, including production
  - Emission factors
  - Emissions
- **Measurements**
  - Ambient levels: in communities
  - Fence-line: capturing facilities emissions
  - "Staged measurements": site access
  - Airborne: regional surveys and area flux estimation
  - Short-Term vs Long-Term

Representativeness, completeness, accuracy, independent evaluation

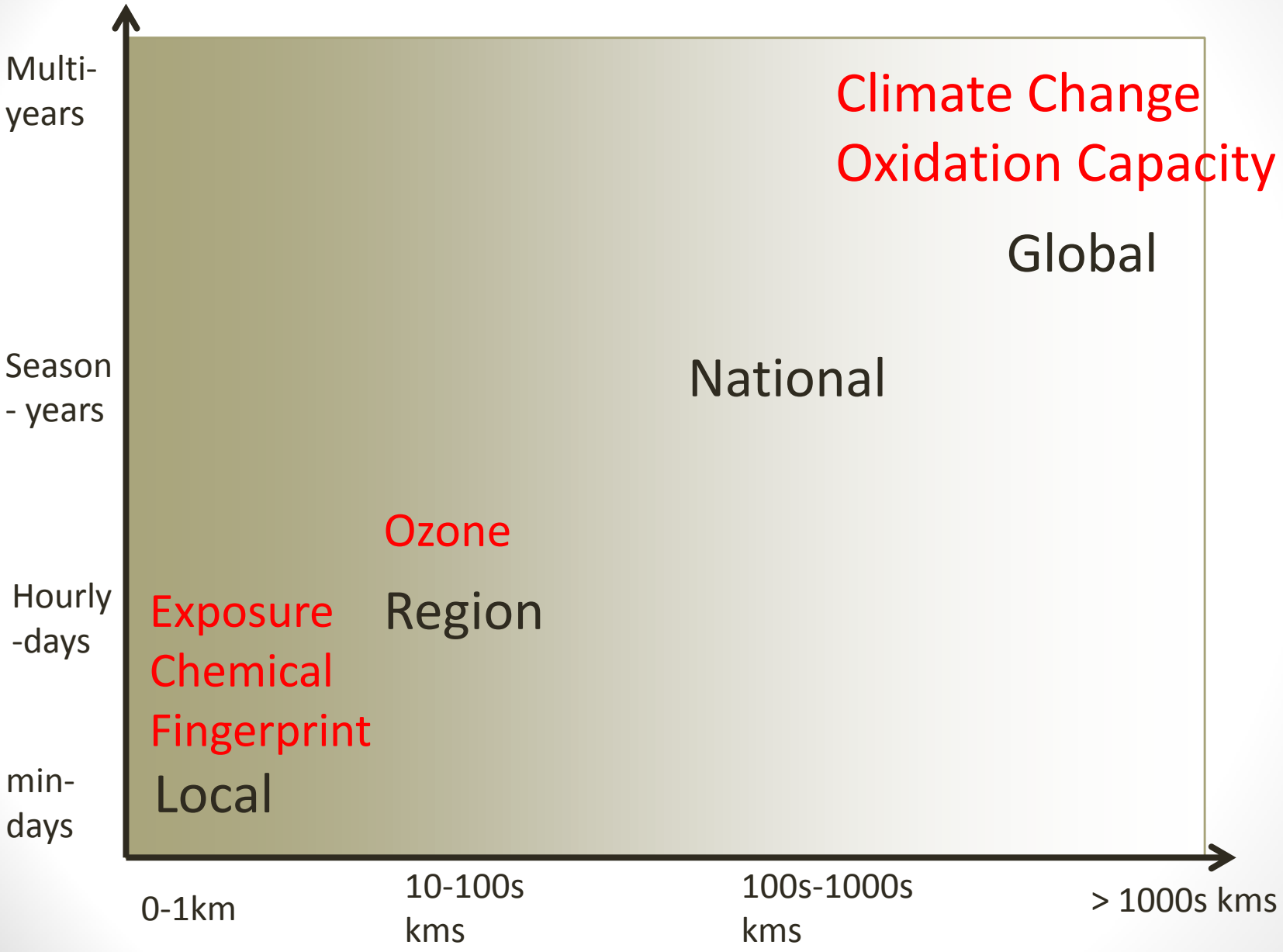
Air Pollutants

- **Composition** of the raw gas and vapors from condensate and crude oil storage tanks, use of additives, type and frequency of surface activities, mitigation practices (flares,…) **can vary greatly** even within one Basin (ex: dry gas vs associated gas)
- **Need to measure a large suite of trace species to cover climate, air quality and health risks and pinpoint emission vectors in different regions**



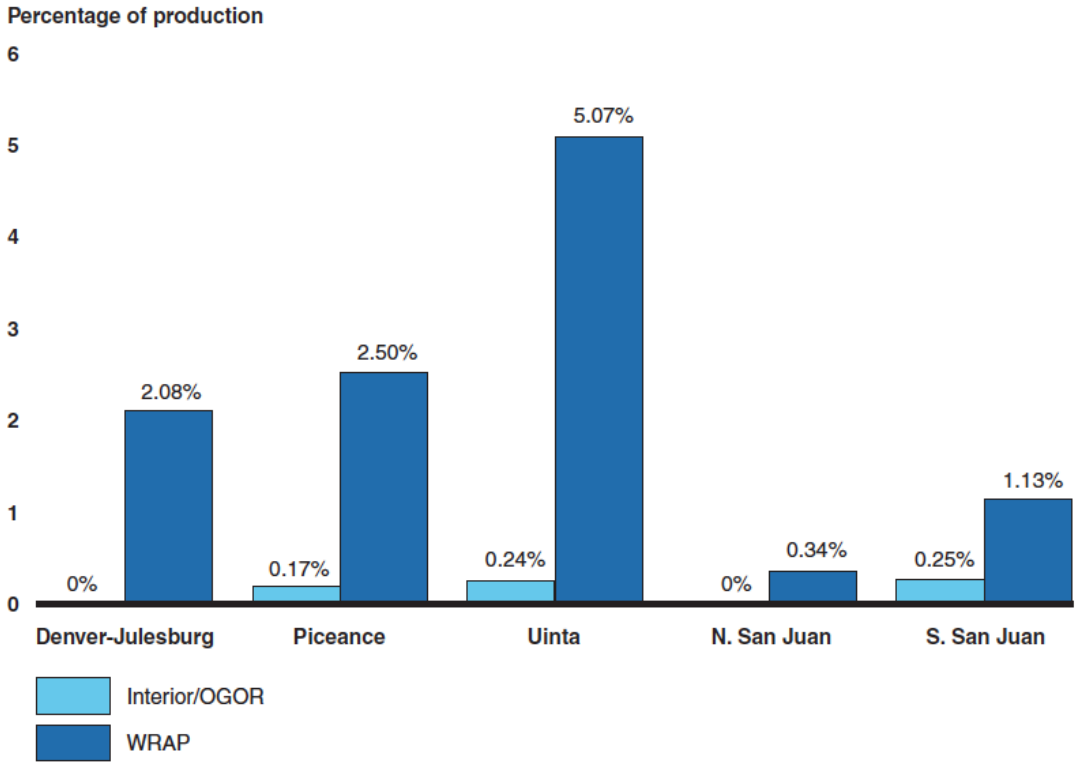



Need for high quality evidence-based information



How robust are flaring/venting numbers?

Figure 3: Comparison of 2006 OGOR-Reported Volumes to Estimates Based on 2006 WRAP Data of Vented and Flared Natural Gas for Onshore Federal Leases in Five Basins



Source: GAO analysis of 2006 WRAP and OGOR data for federal leases.

- How much gas is flared or vented?
  - During completion/flow back
  - During workovers
  - From associated gas wells
- How often is gas flared or vented?
- How green is "green"?

GAO 2010 report on "Federal Oil and Gas Leases. *Opportunities Exist to Capture Vented and Flared Natural Gas, Which Would Increase Royalty Payments and Reduce Greenhouse Gases"*