



Green Week 2013

Session 9.3 - Unconventional fossil fuels (e.g. shale gas) in Europe: addressing climate & environmental challenges



¹Field R.A., ¹Soltis J., ²Borowiak A.
and ²Perez-Ballesta P.

Sharing the U.S. experience of
unconventional natural gas development
with Europe: Assessing impacts upon air
quality

¹University of Wyoming Department of Atmospheric Science

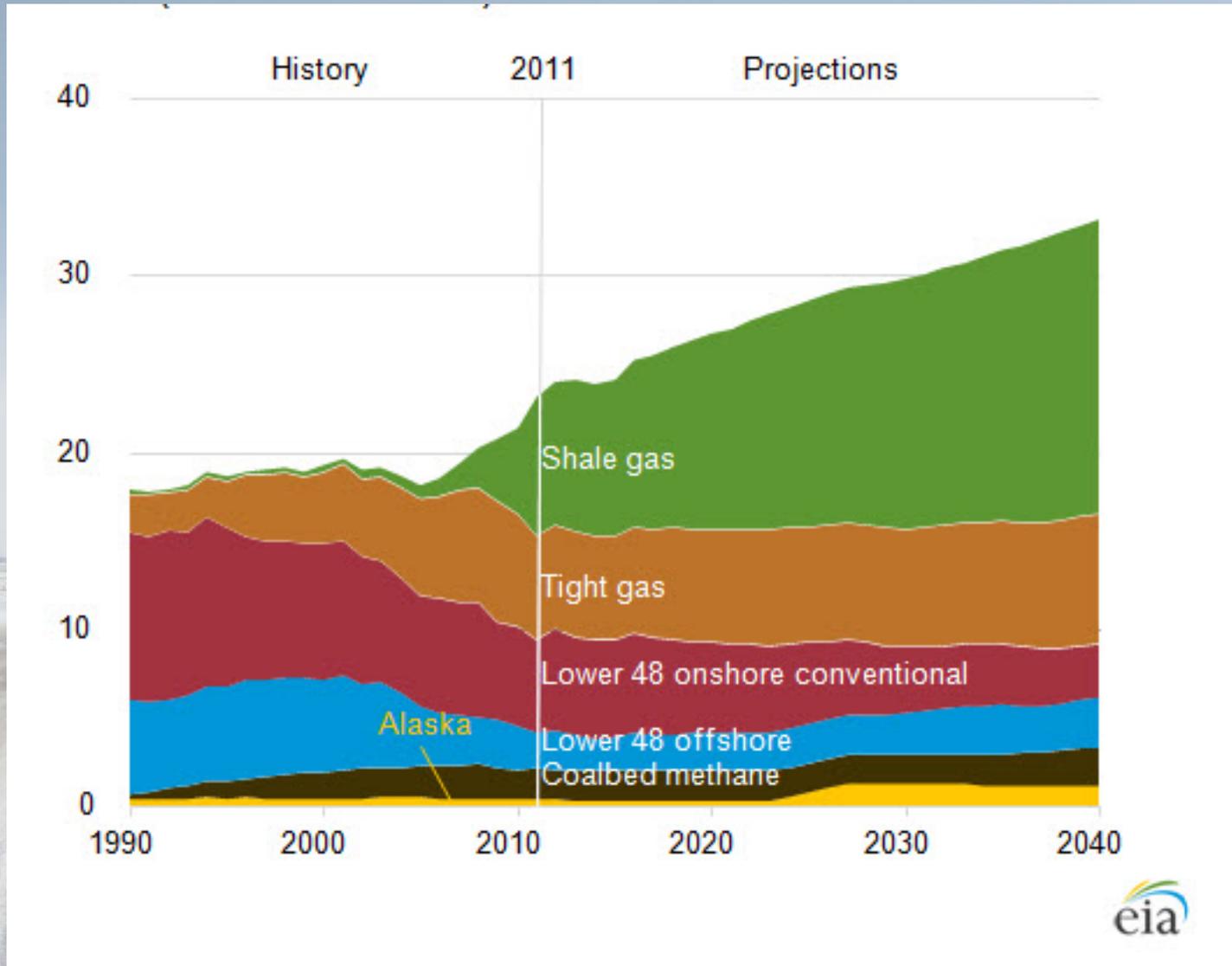
²EC Joint Research Centre, Institute for Environment and Sustainability, Air and Climate Unit



CONTEXT

Unconventional oil and natural gas development in the U.S. is changing the global energy balance

U.S. Natural Gas Production 1990 to 2040 trillion cubic feet



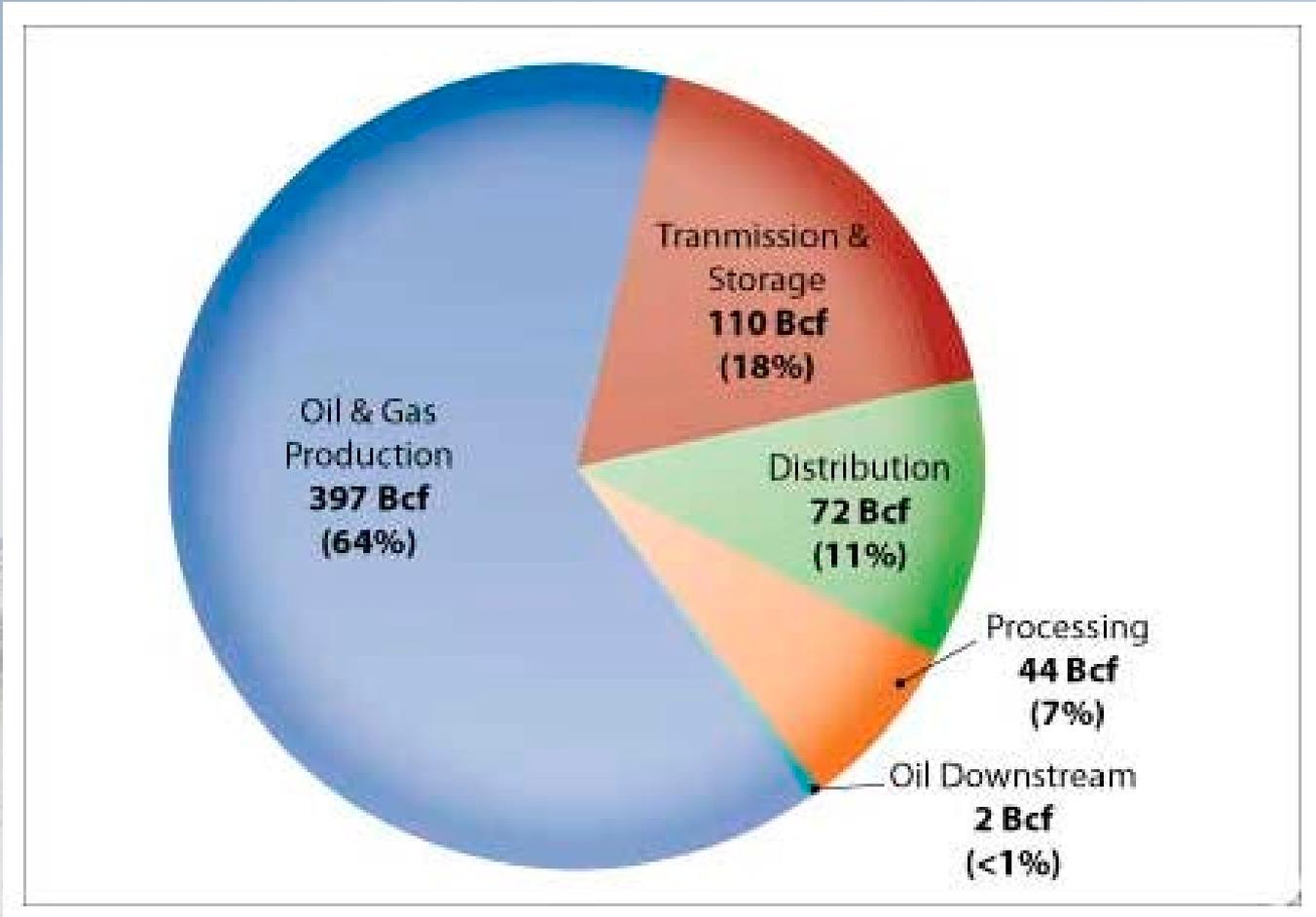


EMISSIONS

**Unconventional
development requires
hydraulic fracturing for
completion and
subsequent production**



CH₄ emissions for oil and gas



Upstream emission sources

Diesel Engines



Wet/dry gas handling



Fluids handling



Development



Completion



Production

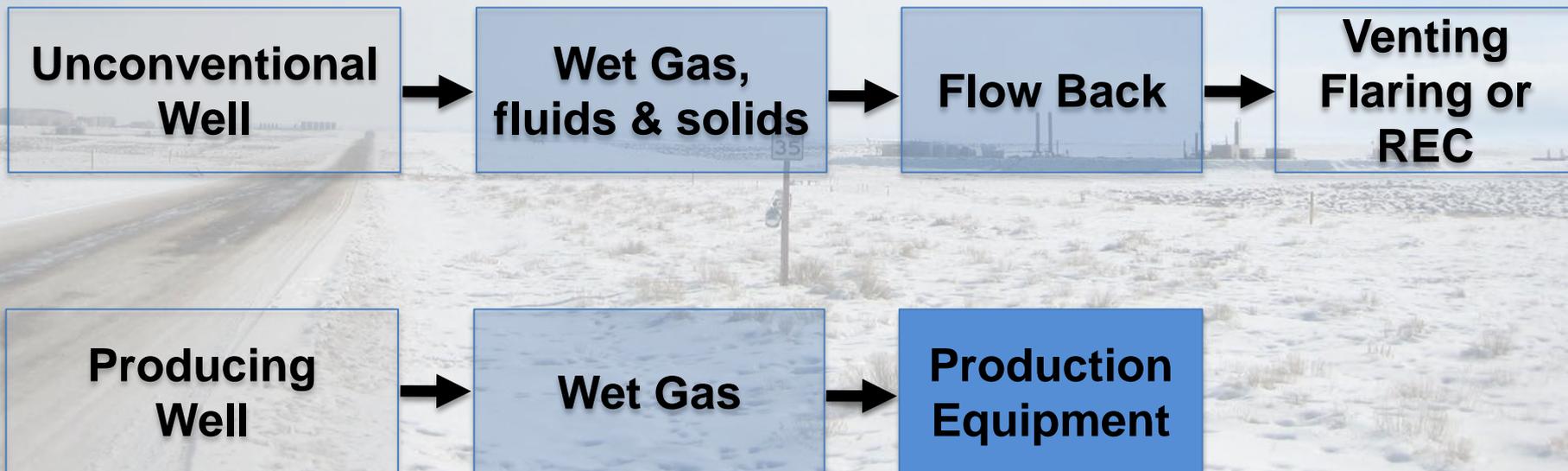


Hopewell PA, National Geographic news



Well Completion

? Mcf (Mm³)/day
for 3-10 days







AIR POLLUTION

**Oil and gas emission
impacts range from
local to global**

Air pollution issues

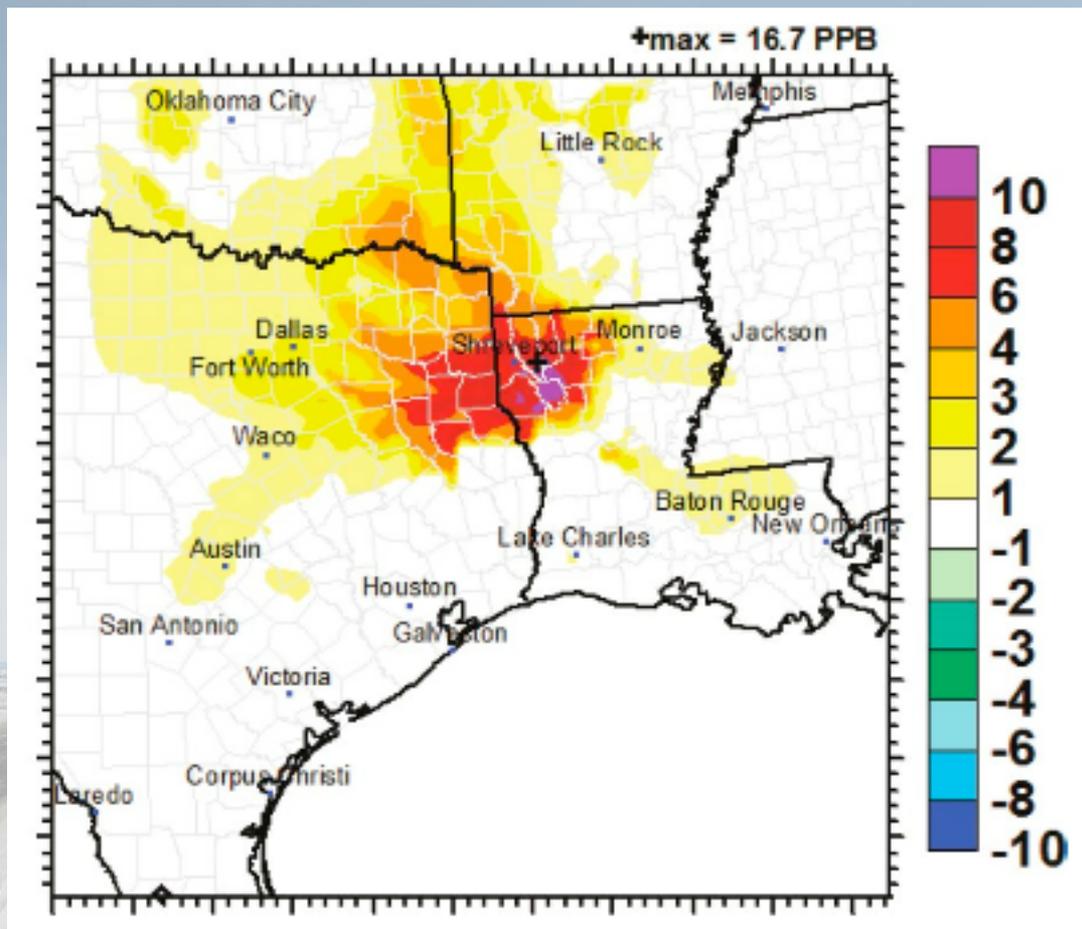
- **Criteria pollutants**
 - O_3 (VOC + NO_x + sunlight)
 - NO_2
 - $PM_{2.5}$
- **Hazardous air pollutants (Air toxics)**
 - **BTEX** (benzene, toluene, ethylbenzene and xylene isomers)
 - **Formaldehyde**
 - **Particulate matter**
 - **Others including certain VOC (e.g. n-hexane) and PAH**
- **Climate forcing pollutants**
 - CH_4
 - **Black carbon**



Criteria Air pollutants

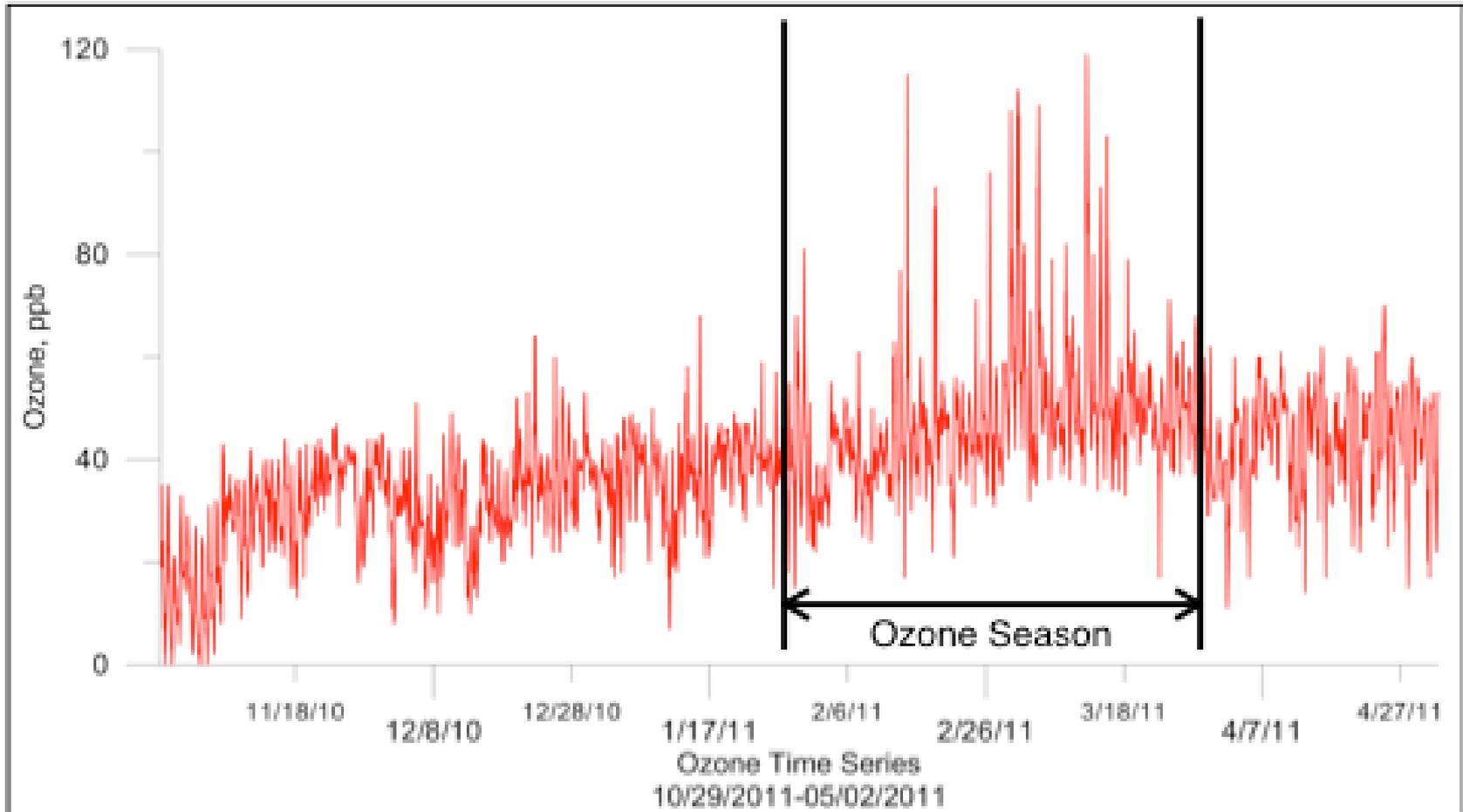
- **Ozone has received the most attention due to significant emissions of precursor compounds, namely VOC and NO_x**
- **Particular attention is paid to the speciation of VOC as reactivity is an important factor**
- **Summer ozone remains an important air quality issue together with the new phenomenon of winter time ozone**

Modeled impact of Haynesville shale gas emissions upon region ozone



Max increase
of daily 8-hr
ozone value

Measured impact of Pinedale Anticline gas emissions upon local ozone





Hazardous Air pollutants

- **Exposure to BTEX has become a driver of assessments as these compounds have defined health impacts and can be released at a number of steps in the development process, namely:**
 - **Flow back fluids from hydraulic fracturing process**
 - **Production and dehydration of wet gas**
 - **Tank storage and transfer of condensate**
 - **Pond evaporation and water treatment**

Water treatment facility



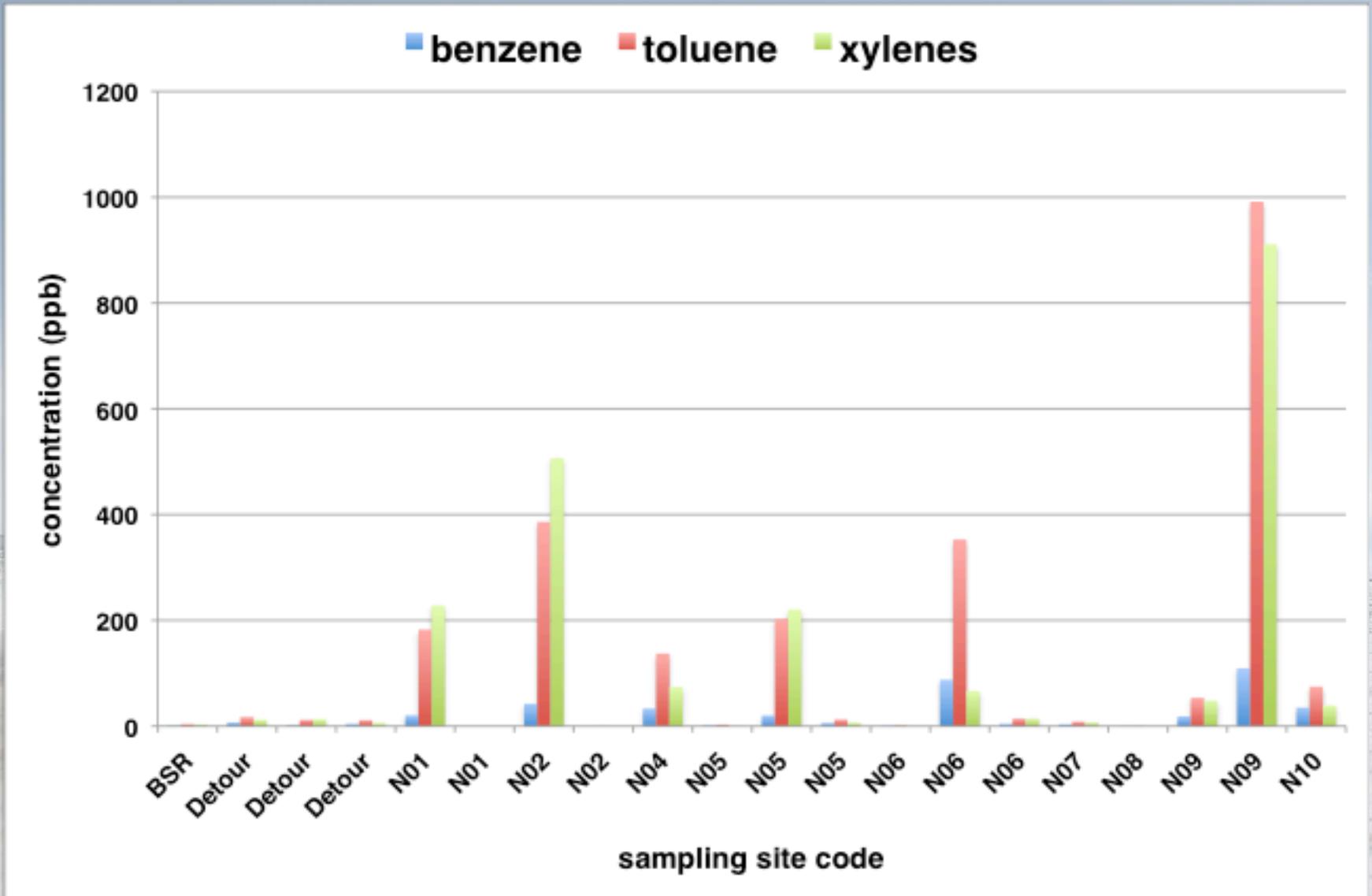
Pinedale Anticline disposal facility

- Since 2006 over 20 million barrels processed
- Capacity of 60,000 barrels/day for processing and 20,000 barrels/day for discharge
- Typical Feed 28,000 to 80,000 $\mu\text{g/L}$ of BTEX

Fence-line Survey 2012



Facility survey results





Climate forcing pollutants

- **The controversy regarding the methane emission rates from oil and gas operations is at the center of a wider debate of the relative costs and benefits of coal and natural gas as agents of climate change:**
 - **How much methane is released during completion flow back operations?**
 - **How much methane is emitted in the lifetime of a well and from the wider supply chain?**



Methane Emissions as % of Well Lifetime Production

	Conventional %	Unconventional %
Well Completion*	0.01	1.9
Venting and Leaks at pad	0.3 to 1.9	0.3 to 1.9
Liquid uploading	0 to 0.26	0 to 0.26
Gas processing	0 to 0.19	0 to 0.19
Transport, storage, distribution	1.4 to 3.6	1.4 to 3.6
Total emissions	1.7 to 6.0	3.6 to 7.9

* Flow back 1.6% & Drill out 0.3%

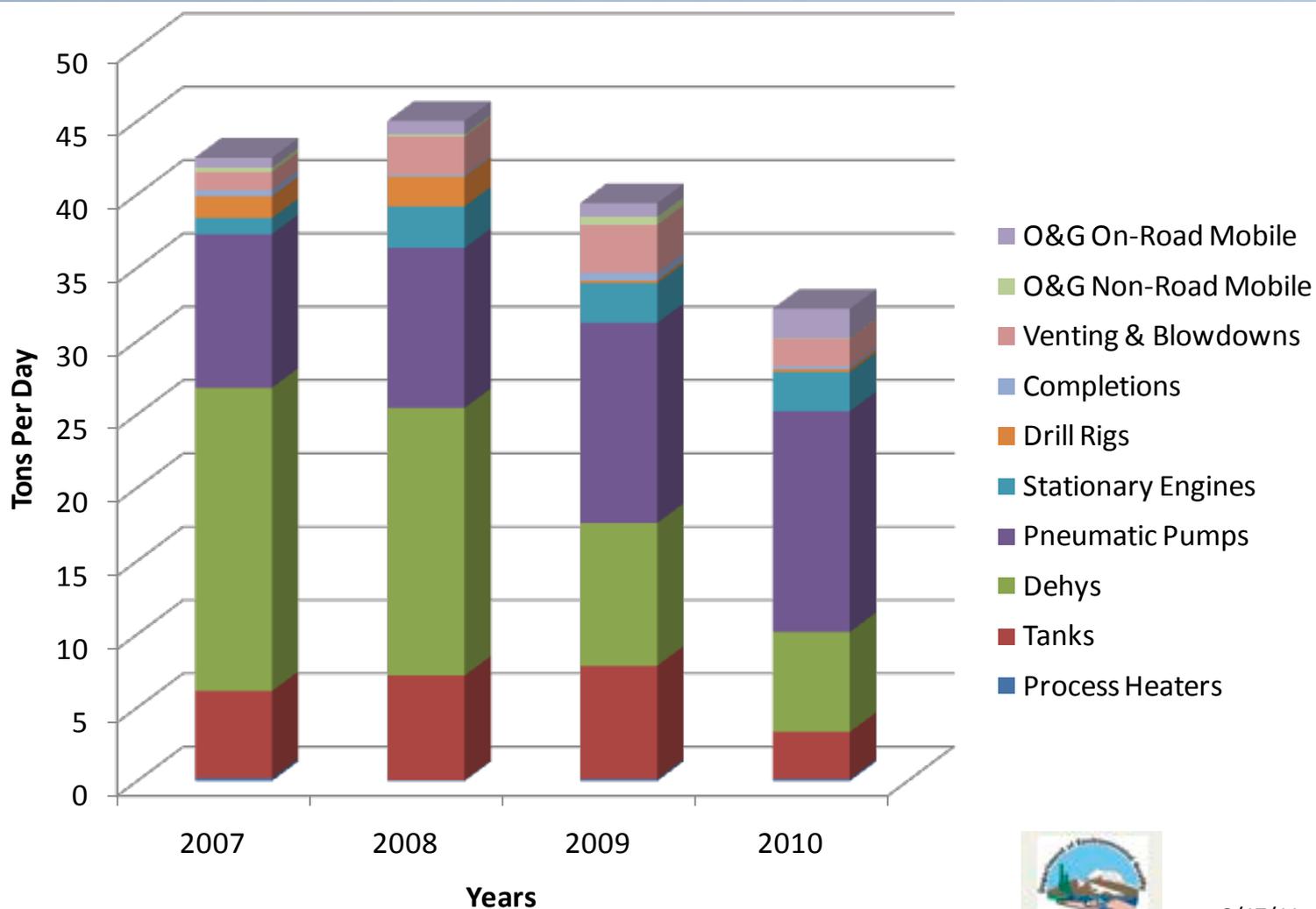


ASSESSMENT I

**Emission inventories are
the basis for modeling
assessments of
potential impacts**



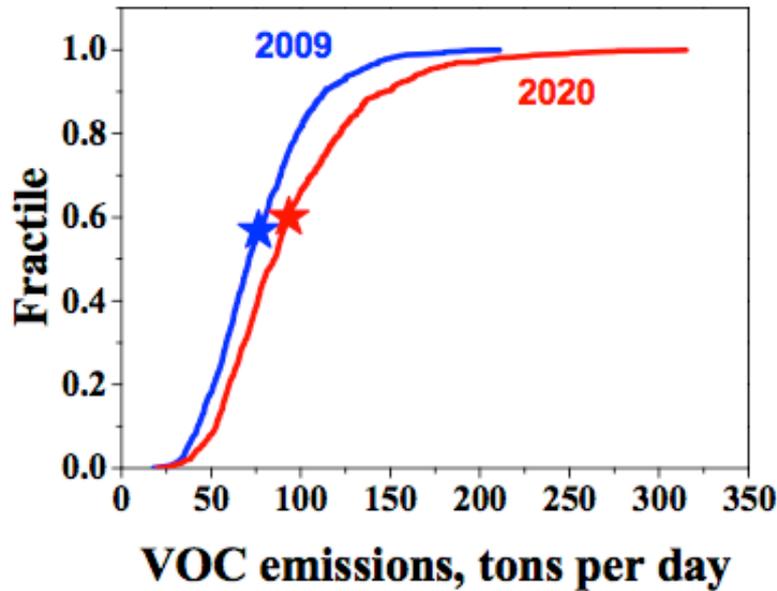
Sublette County Daily Winter VOC EI



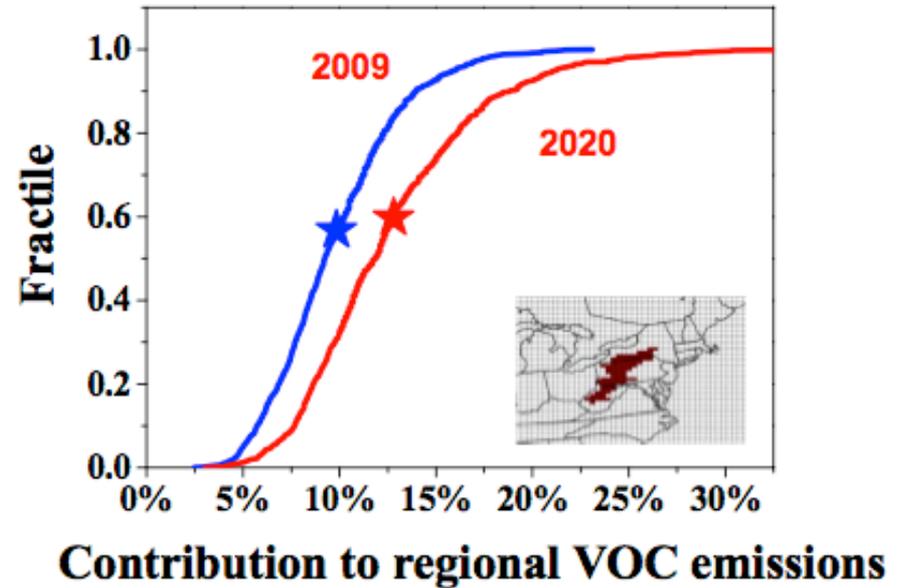
rev 3/17/11

Marcellus VOC emissions

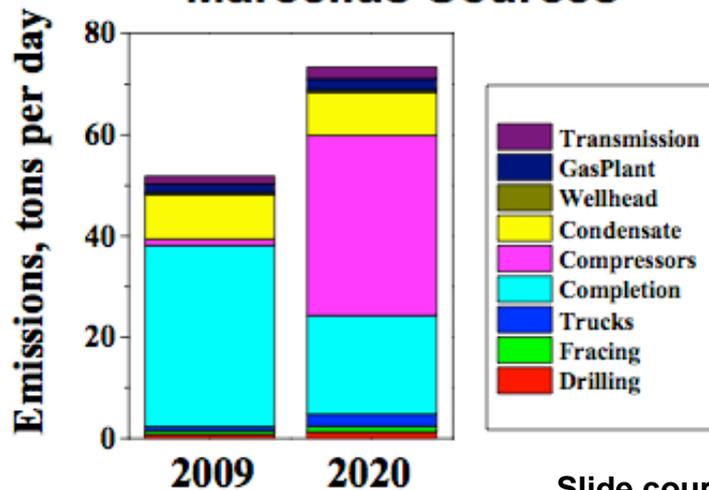
Marcellus Emissions



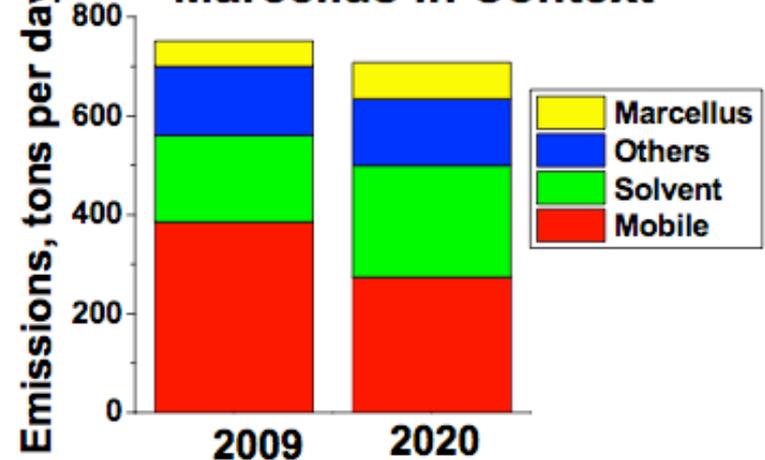
Regional Contribution



Marcellus Sources



Marcellus in Context



Slide courtesy of Dr. Robinson Carnegie Mellon

Source	NOx	VOC	PM	Air Toxics	Data Quality
Well development					
Drill Rigs	●	●	●	●	Medium
Frac Pumps	●	●	●	●	Medium
Truck Traffic	●	●	●	●	Medium
Completion Venting		●		●	Poor
Frac ponds		●		?	Poor
Gas Production					
Compressor Stations	●	●	●	●	Medium
Wellhead compressors	●	●	●	●	Medium
Heaters and dehydrators		●	●	●	Medium
Blowdown venting		●		●	Poor
Condensate Tanks		●		●	Poor
Fugitives		●		●	Poor
Pneumatics		●		●	Poor

● = major source

● = minor source



What is the Problem with Emission Inventories?

- **An EI is an accountancy tool not reality**
- **Reliance upon emission factors derived from limited data**
- **Constructed with self reported data**
- **At present completion and evaporative emissions not reported properly**
- **Even if perfectly constructed will not reflect ground truth**

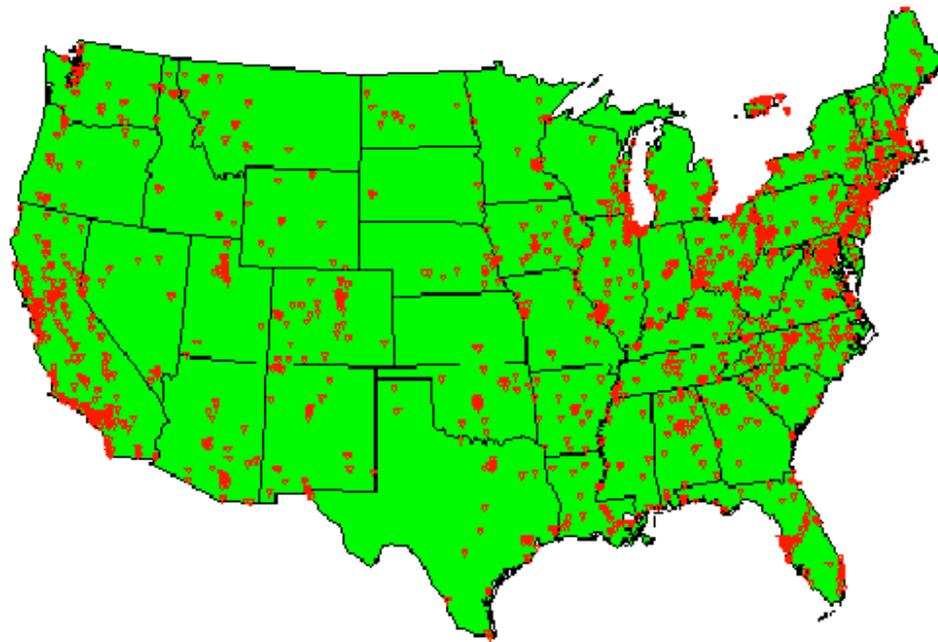


ASSESSMENT II

Monitoring is required for realistic determination of pollution exposure and as the basis of health impact assessments

Limited ambient air quality data

- Poor coverage of oil and gas development by existing monitoring networks
- New stations are being established, however limited pre-development monitoring has been purposely performed



State and local air monitoring network stations

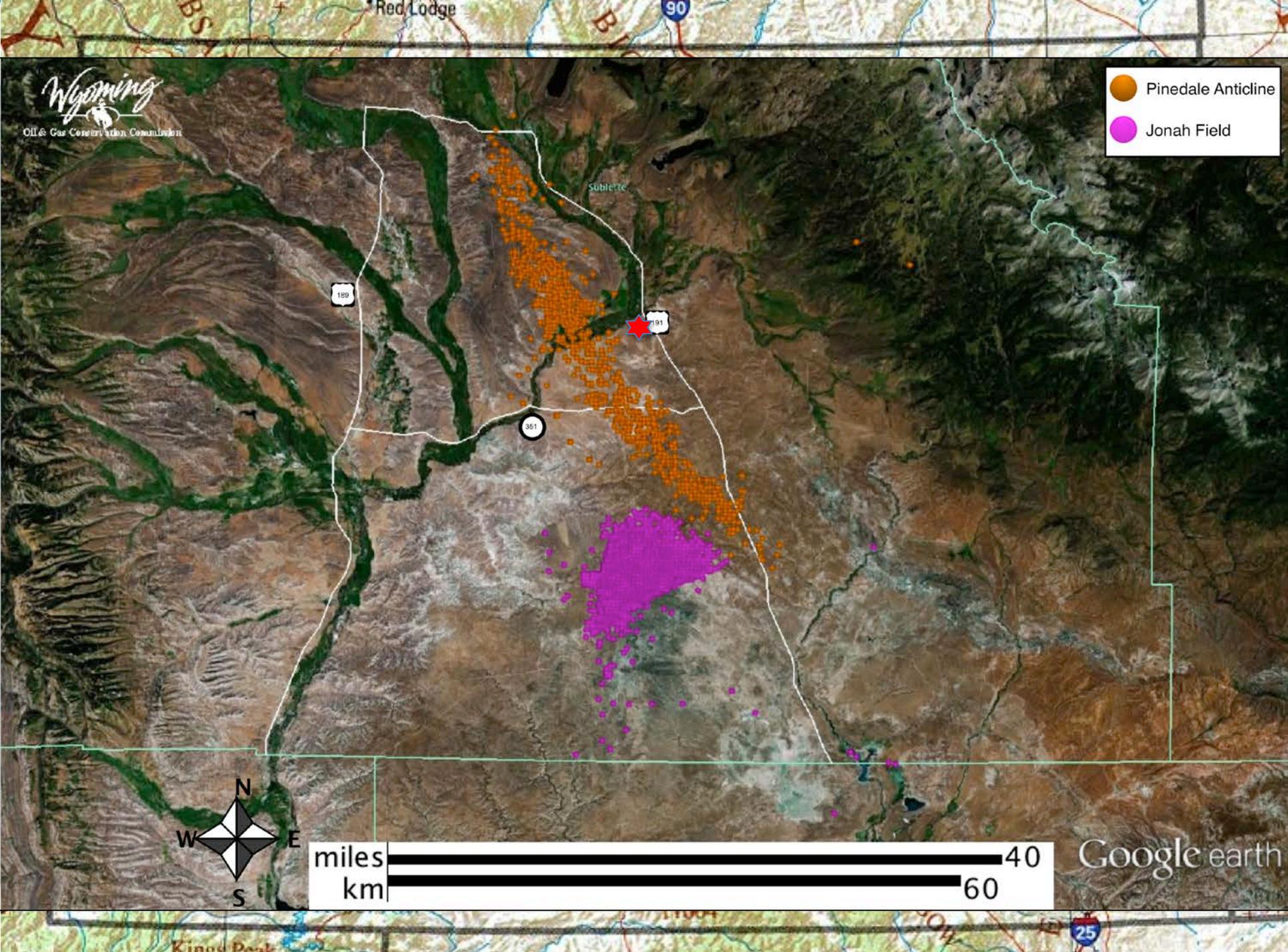
Lower 48 states shale plays



Special studies also required e.g. PASQUA project Wyoming

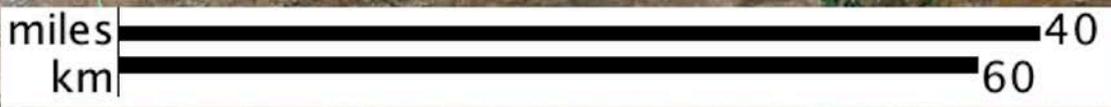
**Temporal,
Spatial & Mobile
measurements
of the impact of
natural gas
emission
sources**





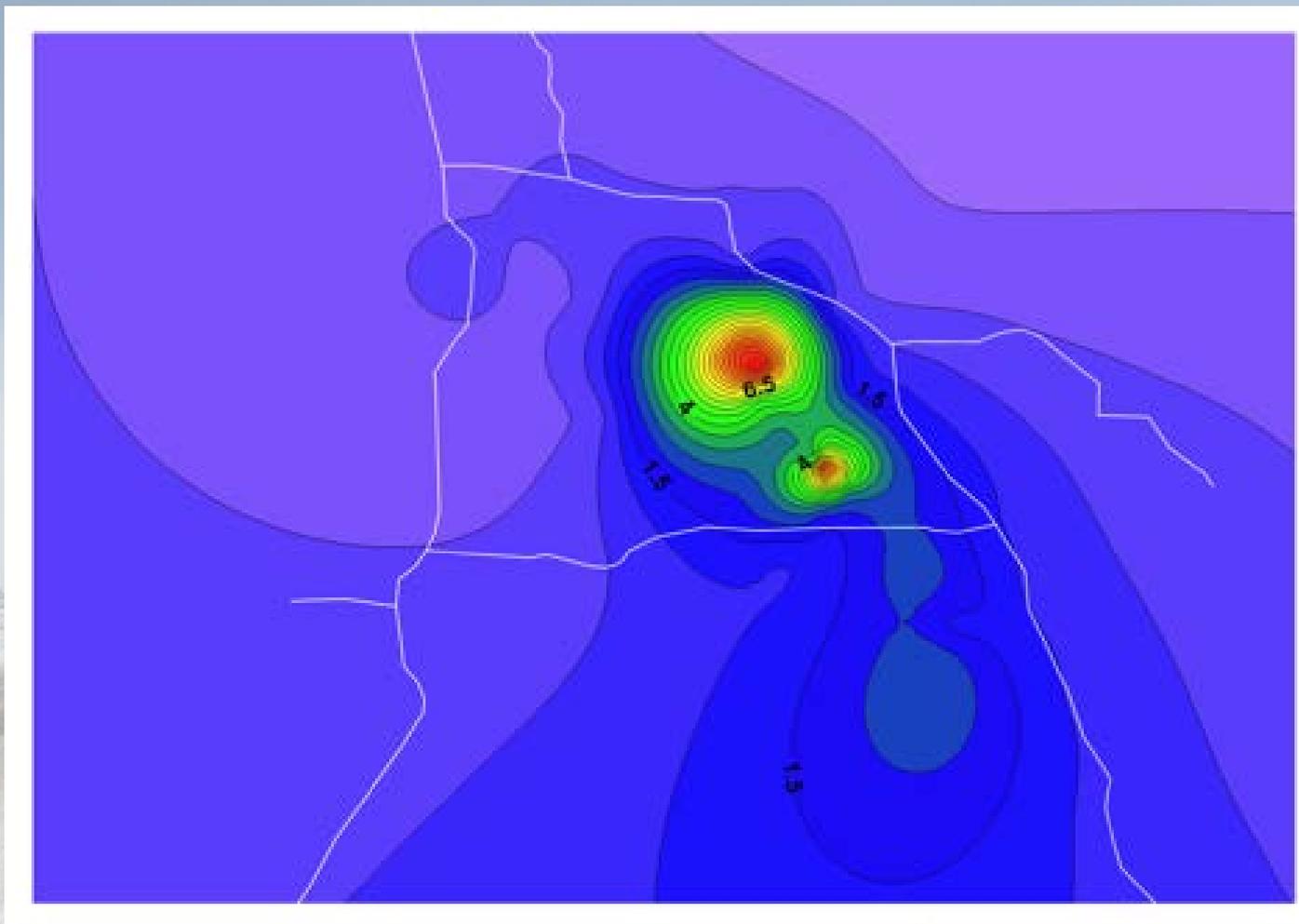
- Pinedale Anticline
- Jonah Field

Wyoming
Oil & Gas Conservation Commission



Google earth

Diffusive Sampling as a cost effective screening tool (BTEX)



Toluene (ppb) 02/7 – 02/10 2012 in the Pinedale Anticline project area, Sublette County WY₃₁

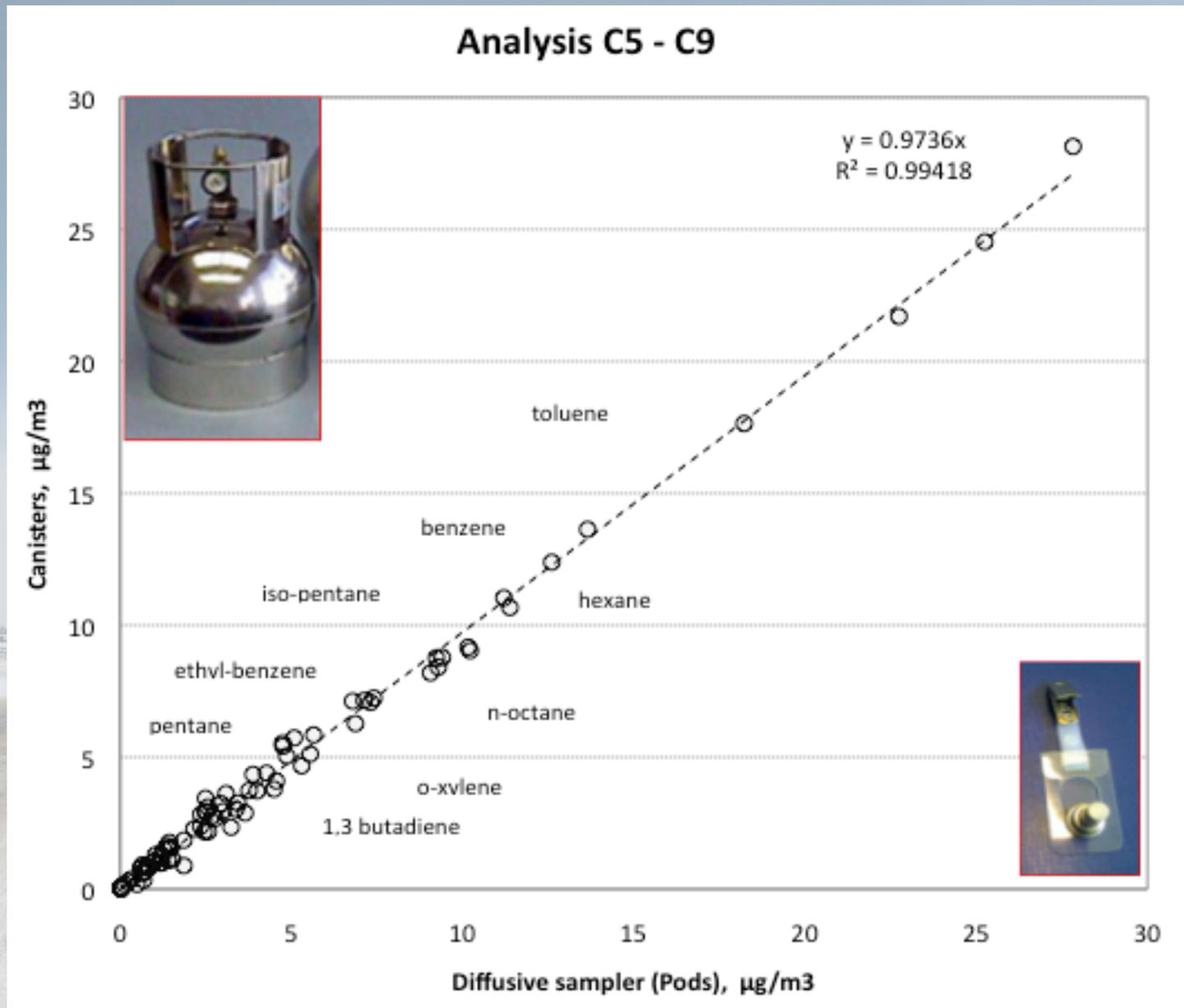
Next Generation Diffusive Samplers:



**Joint Research
Centre PODS**

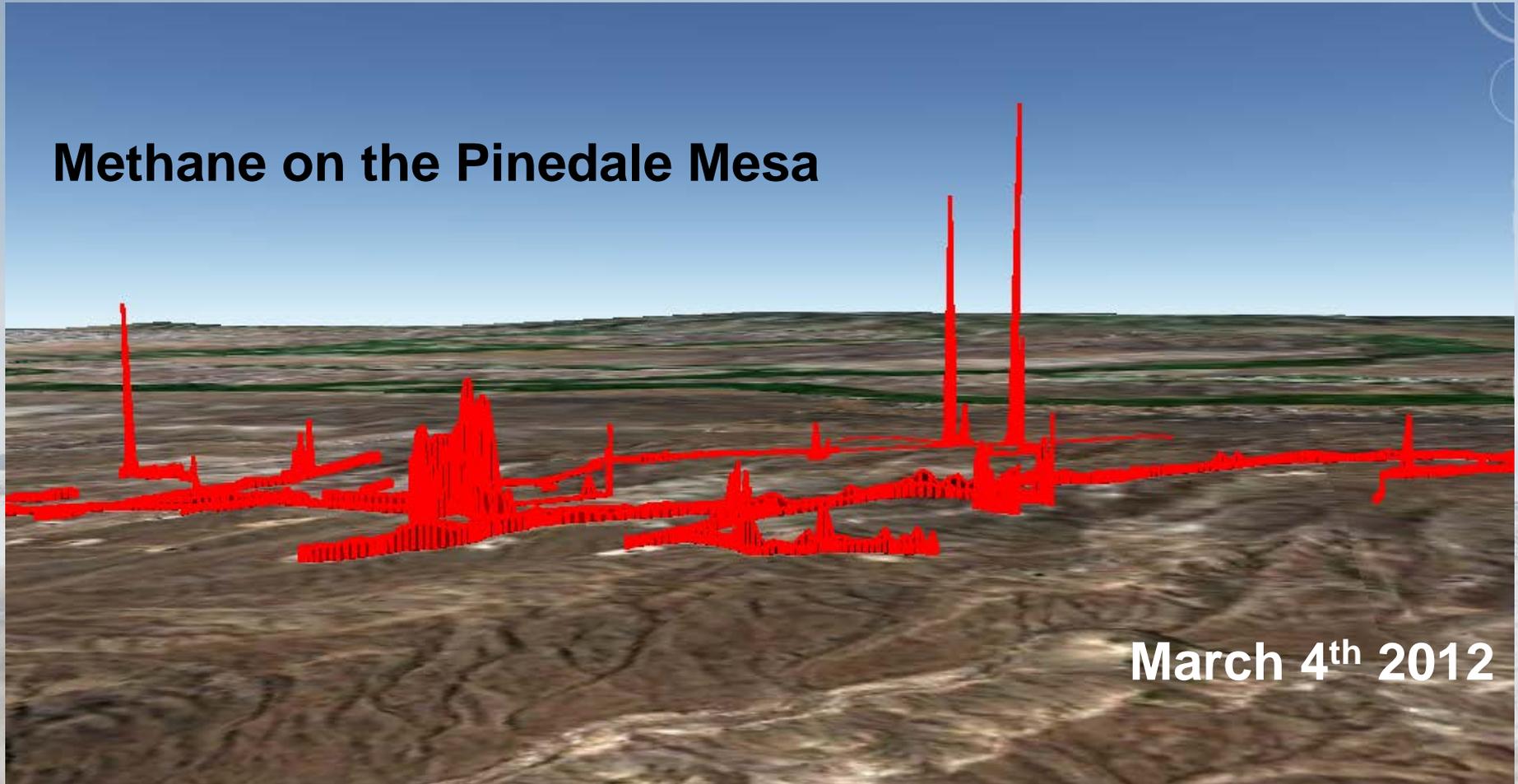
**Patent
Approved**

Excellent performance and range



The power of mobile monitoring

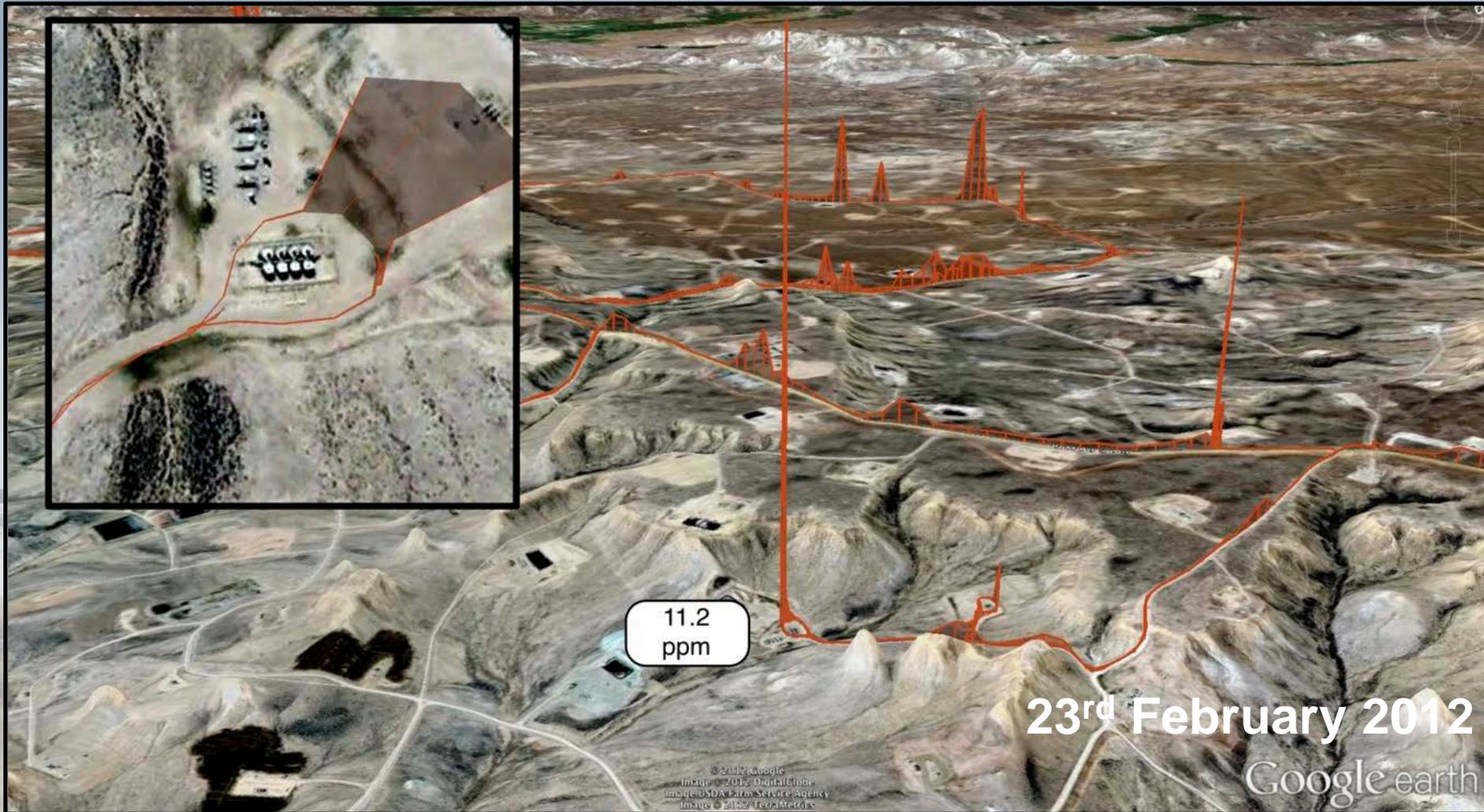
Methane on the Pinedale Mesa



March 4th 2012

Picarro Mobile methane system

Quantification of emission plumes



RECENT INITIATIVES

- **June 1st 2013 EPA Upstream National Emission estimation tool for county level released**
- **September 2013 EDF study to better define Texas oil and gas emissions through measurements**
- **NIOSH and NETL initiative with possibility of worker exposure assessment signed April 2013**
- **EPA Oil and Gas Rules Revised 2012 for implementation in 2015.**
- **BLM oil and gas regulations published May 17th 2013**
- **FracFocus and FracTracker**
- **Common ground initiatives e.g. U.S. National Academy of Sciences**



CLOSING REMARKS

- **Proven technologies and management approaches can reduce the impact of emissions**
- **Emission factors are now an EPA priority for improvement**
- **Air quality impact assessment requires carefully coordinated air quality monitoring approaches**
- **Health impact assessments are needed to determine risks**

Thank You & Questions?

