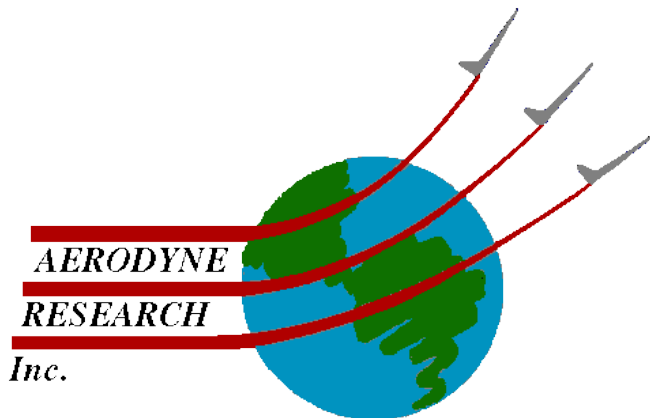


Ground-Based Measurements of Ethane to Methane Ratios in the Barnett Shale

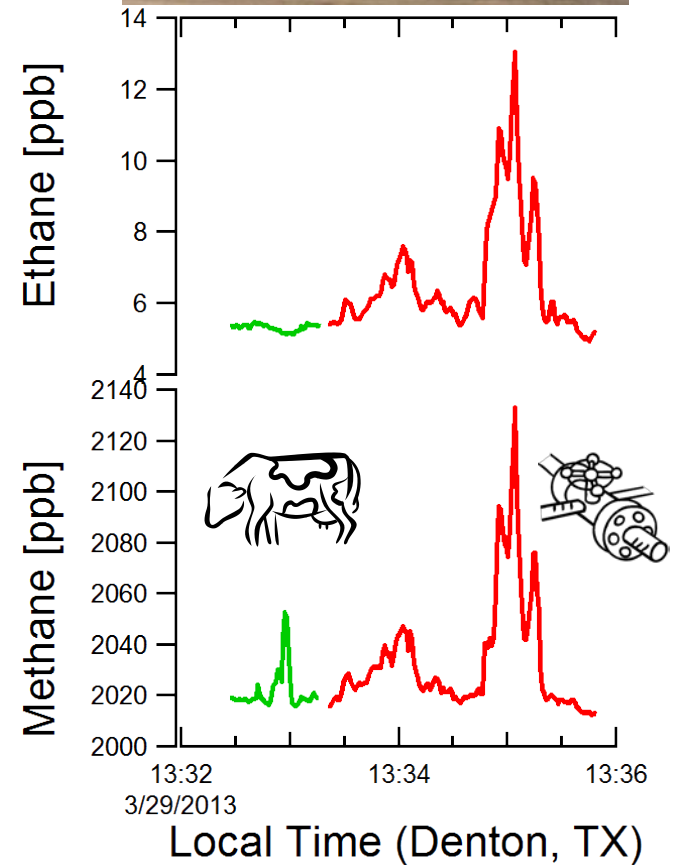
BOGOS 2013



Tara Yacovitch
Aerodyne Research, Inc.



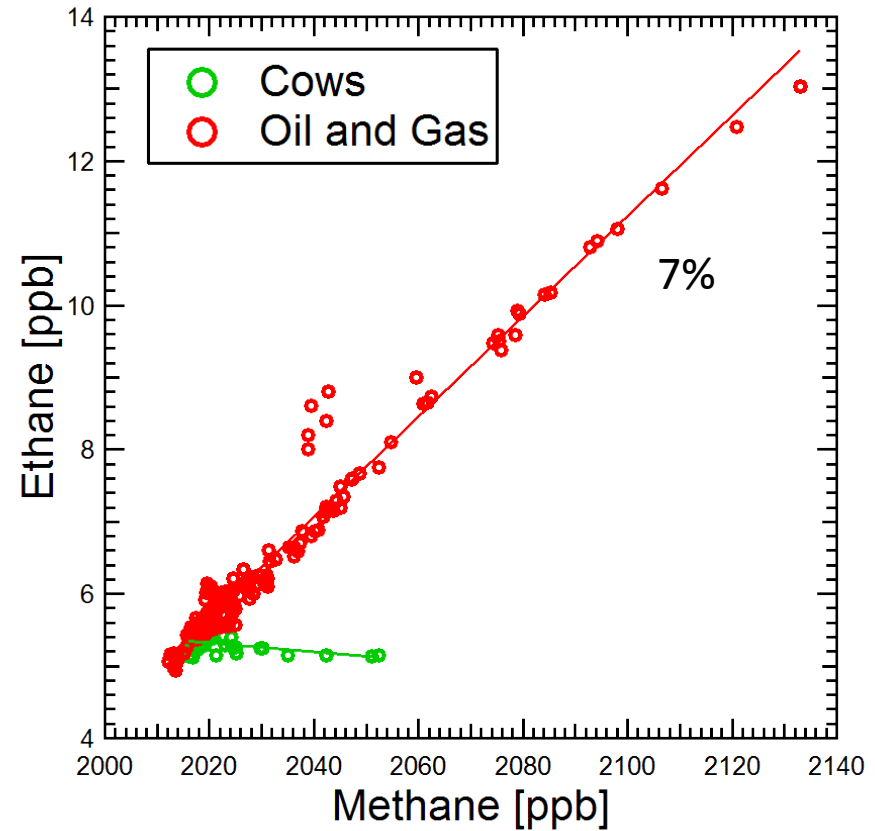
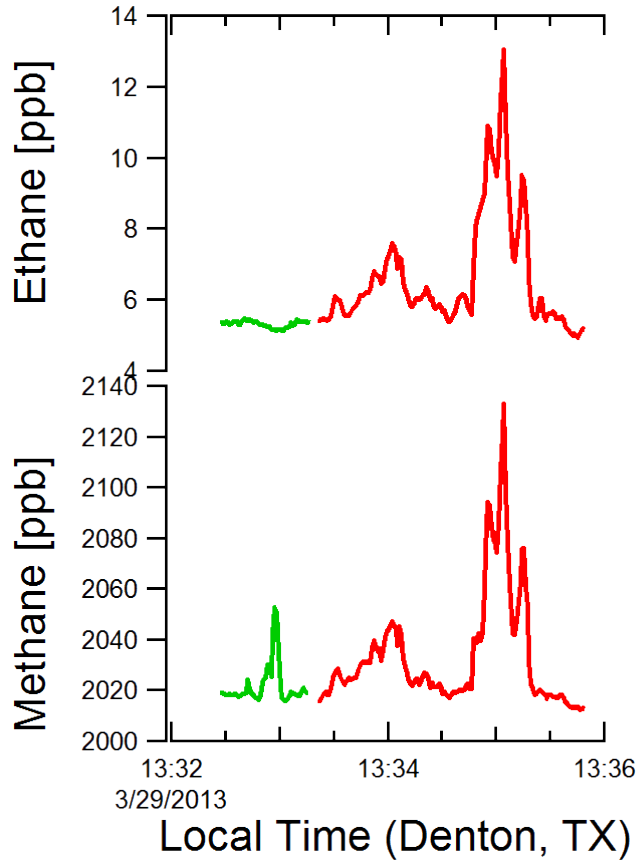
Methane and Ethane



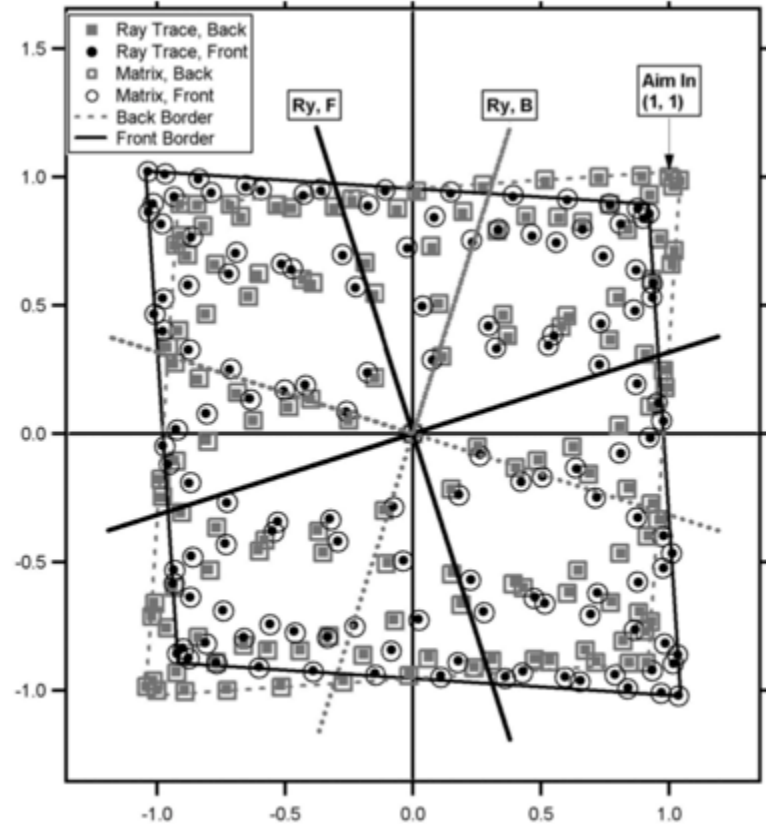
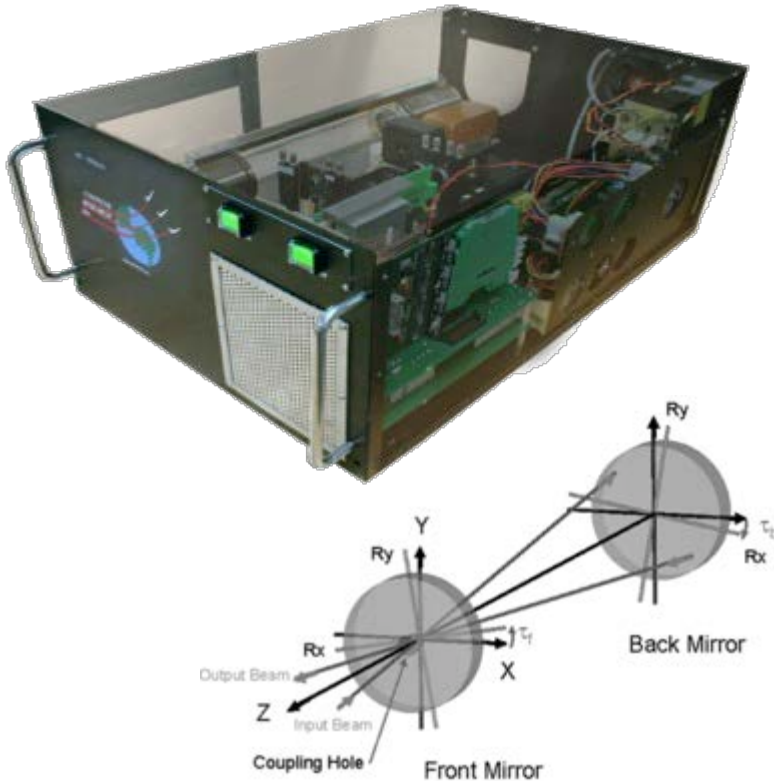
Wind
from SSW
160°
5 m/s

tick spacing = 1000

Biogenic vs Thermogenic Methane



Aerodyne's Ethane Mini: Direct Absorption

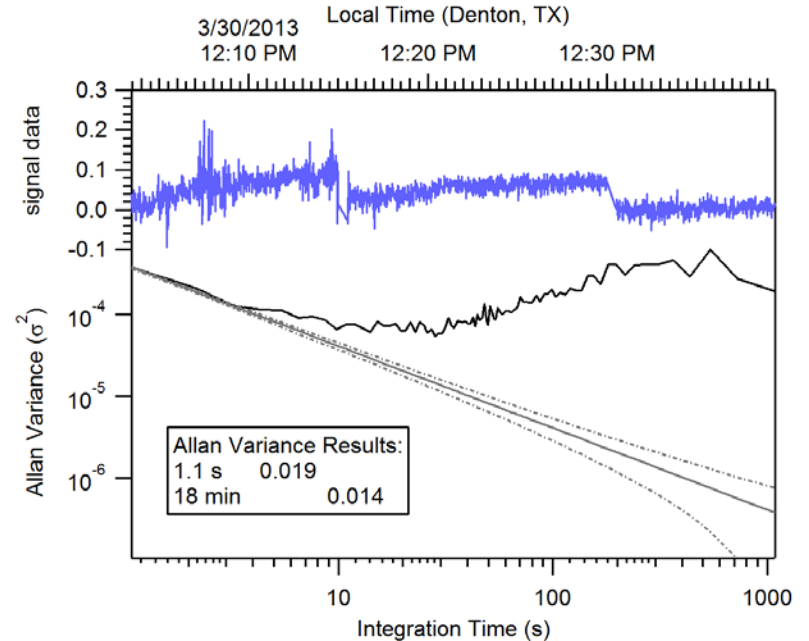
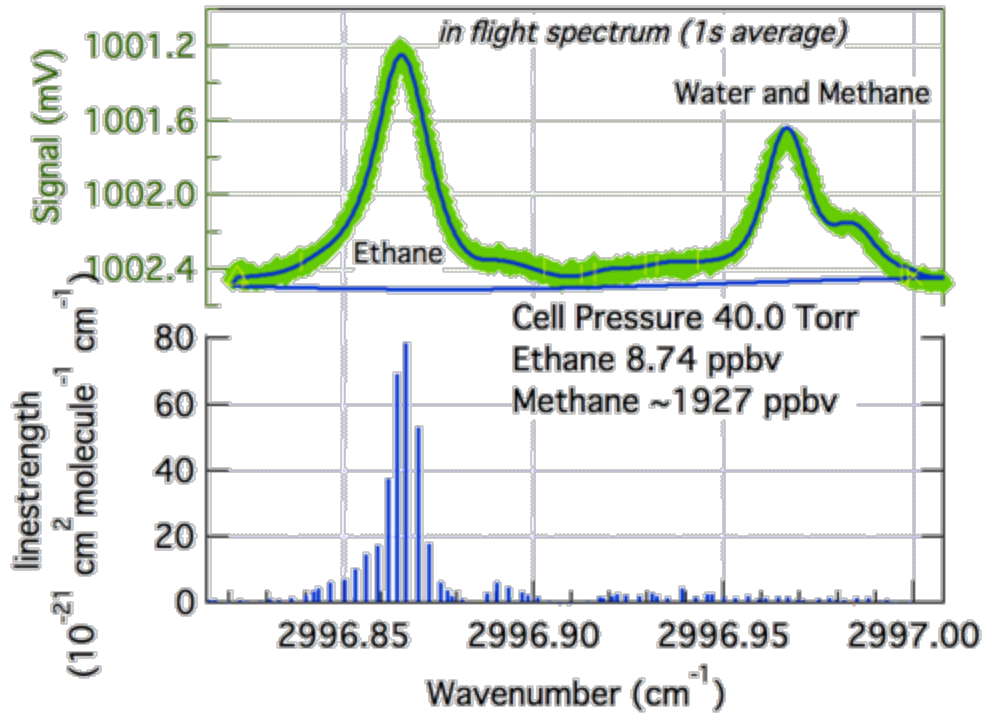


Synthetic ray-trace simulations compared to digitized spot photos of a visible trace beam further corroborate light propagation along a known path through the multipass cell

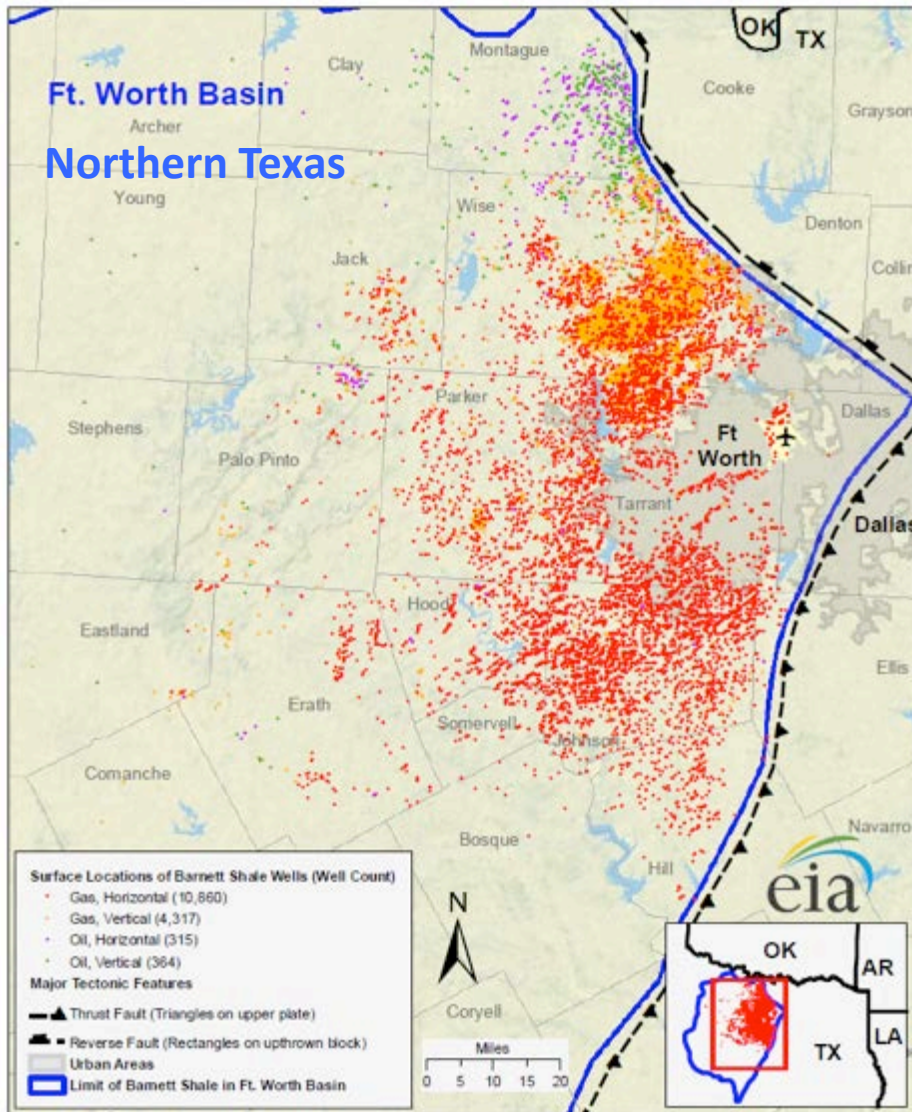
$$A(h\nu) = \text{linestrength}(h\nu) * [\text{concentration of absorber}] \text{length}$$

One or two football fields of length folded into absorption cell

Spectrum and Performance



Barnett Shale Play



~ 16,000 wells

2012 NG Production:

- 2 Trillion cf
- ~ 8% of US total gas production

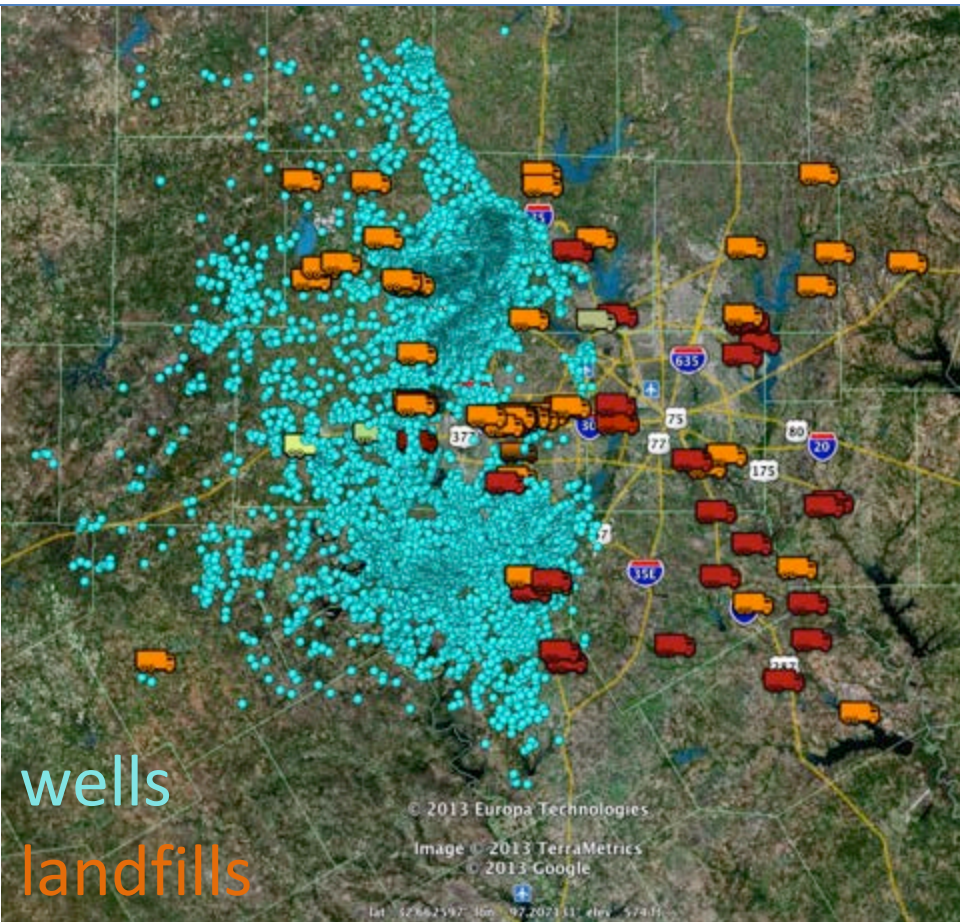
March/April 2013

Intensive campaign to quantify CH_4 emissions from oil and gas operations in the Barnett Shale

NOAA, CU, UC Davis, Aerodyne, Picarro, Shell

Airborne and Ground components

How to Partition the Methane?



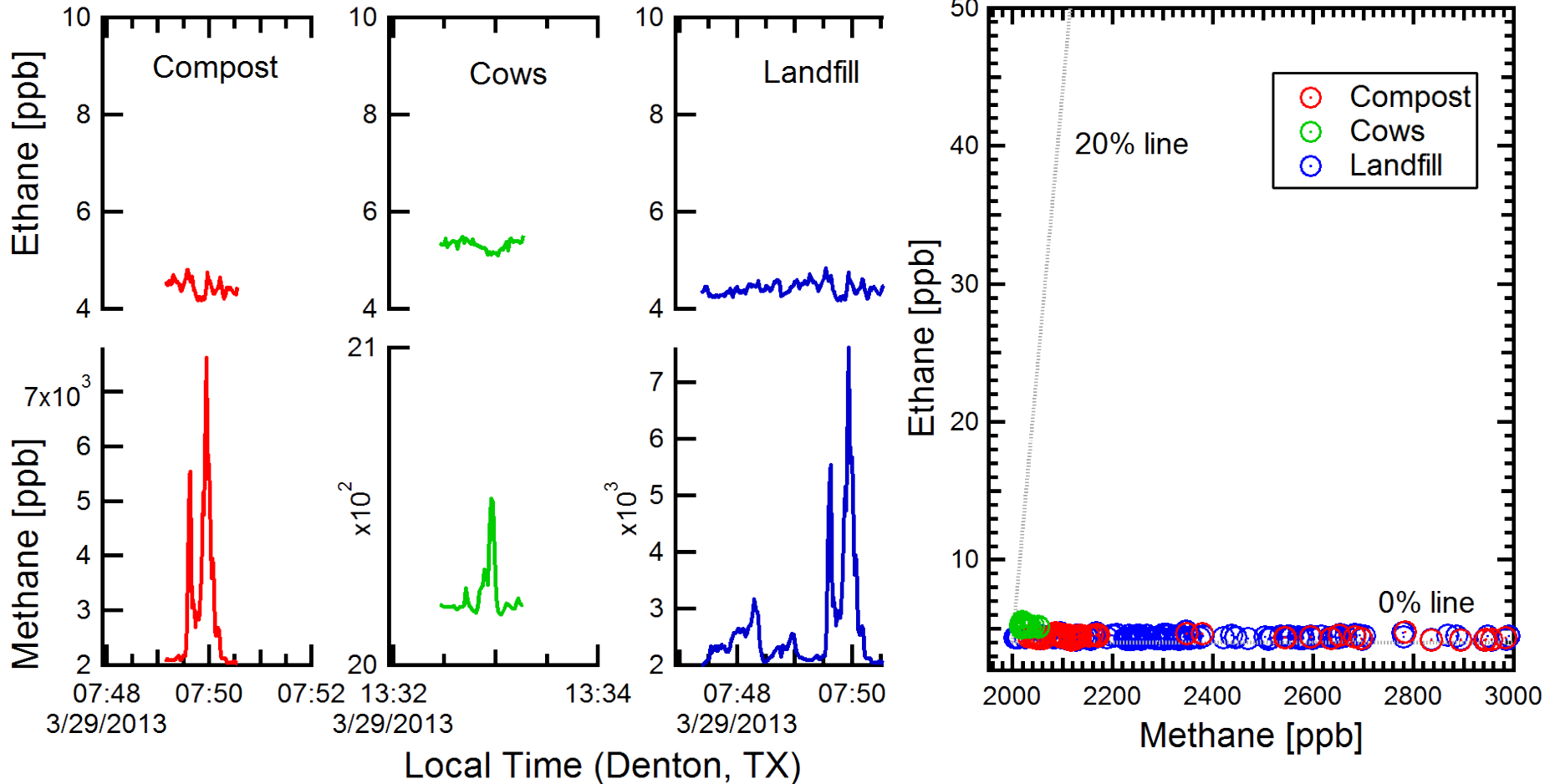
Goal: Quantify methane from oil and gas

Complication: major urban centers: Dallas and Fort Worth.

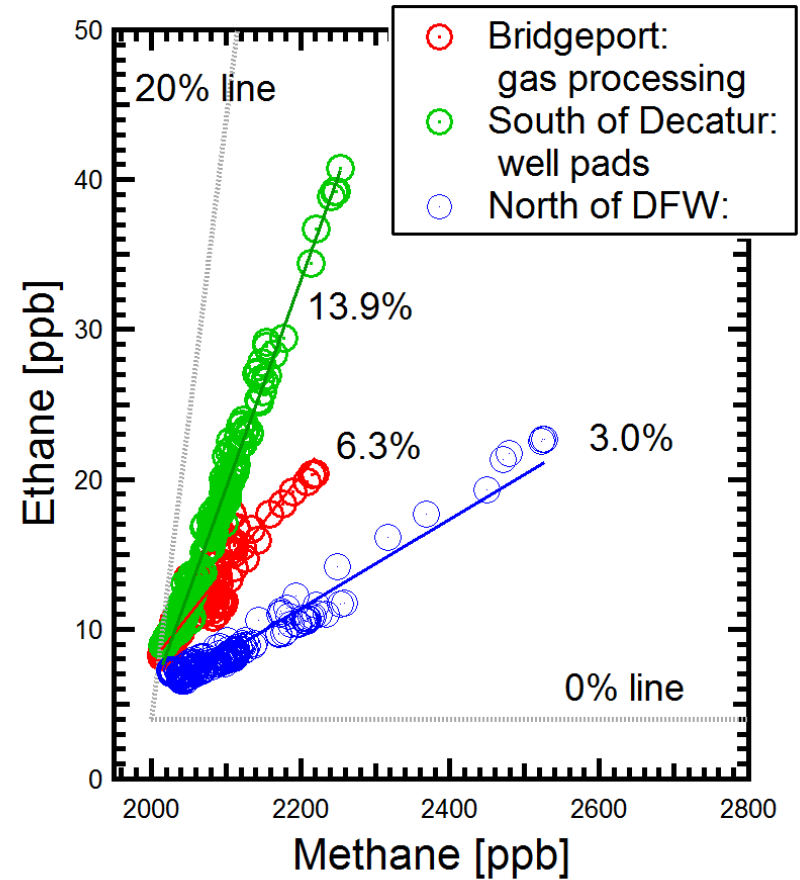
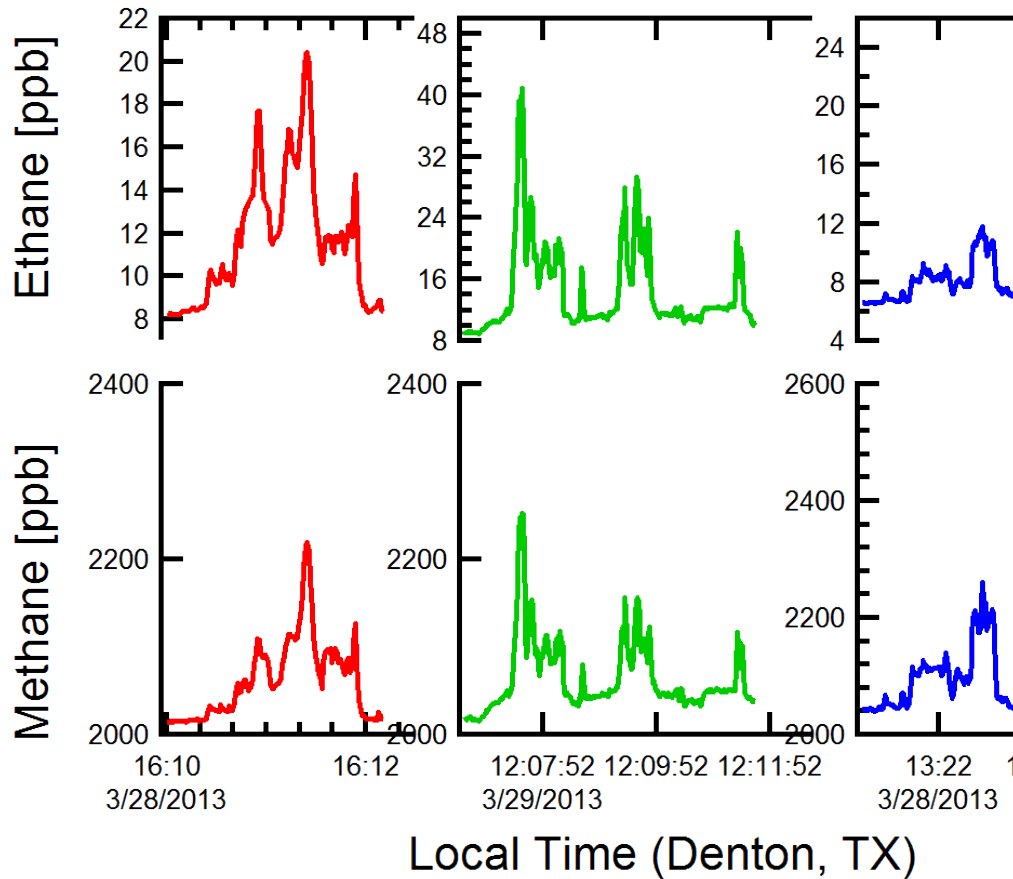
Landfills
agricultural sources.

How does one separate the emission contributions from various CH₄ sources?

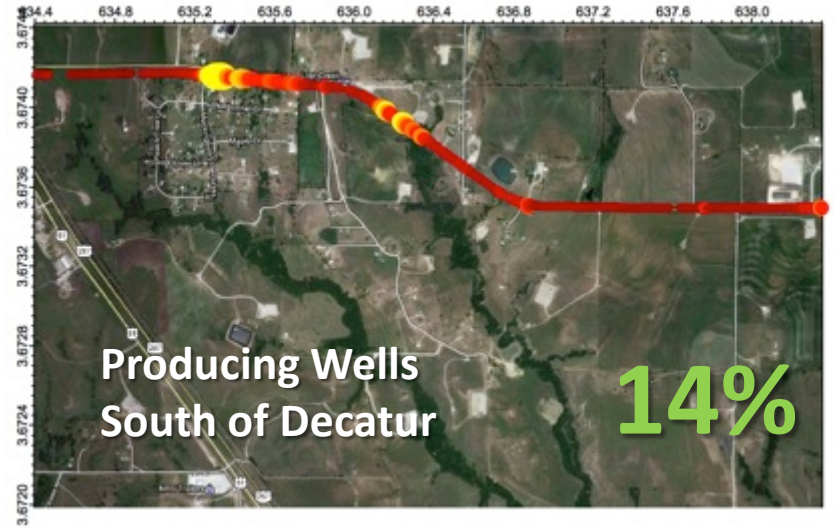
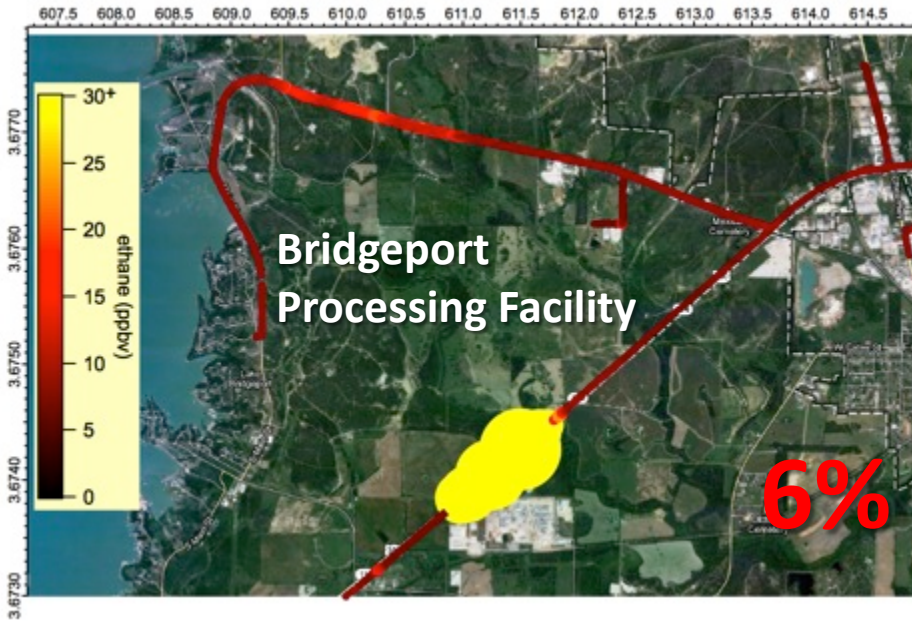
Biogenic Sources



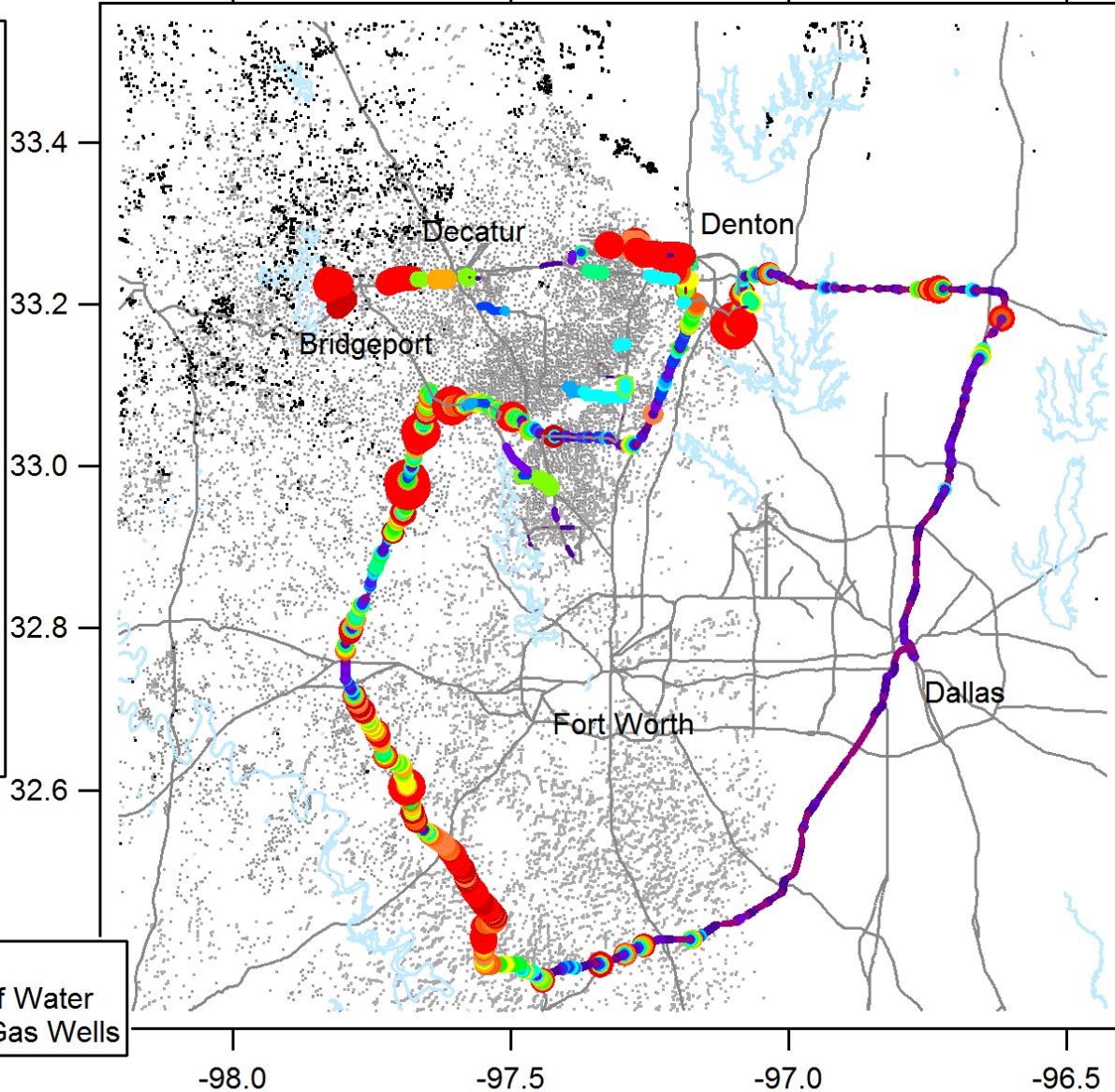
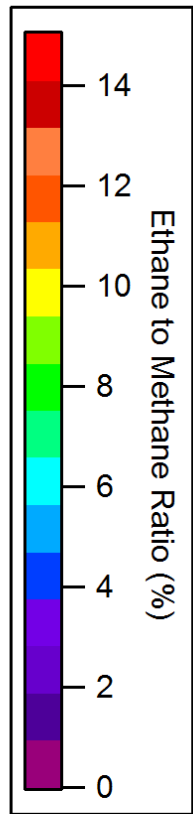
Oil and Gas Sources



Plume Origins

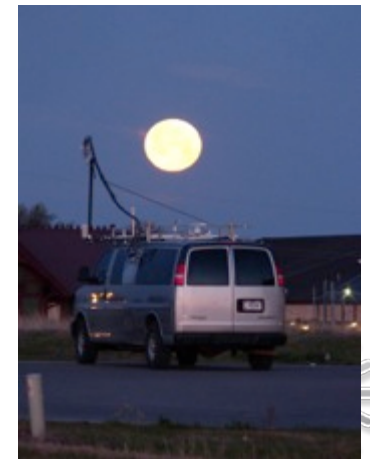


Mapped Ethane to Methane Ratios



Ratio:
-composition
of the gas
-exact
emission
vector (leak,
tank...)

— Roads
— Bodies of Water
• Oil and Gas Wells



Conclusions and Future Work

- Ethane is a powerful tool for source attribution
- Drive data reveals large scale trends and local variability in ratios
- Ground based measurements can be leveraged for use in the analysis of the flight data.

Acknowledgements

- NOAA GMD: Gaby Petron, Jon Kofler, Colm Sweeney, Anna Karion, Sonja Wolter
- Scientific Aviation: Steve Conley
- Picarro: Chris Rella, NOAA van methane instrument
- Aerodyne: Scott Herndon, Cody Floerchinger, Mark Zanhizer

BU Ethane-Methane
January 2013

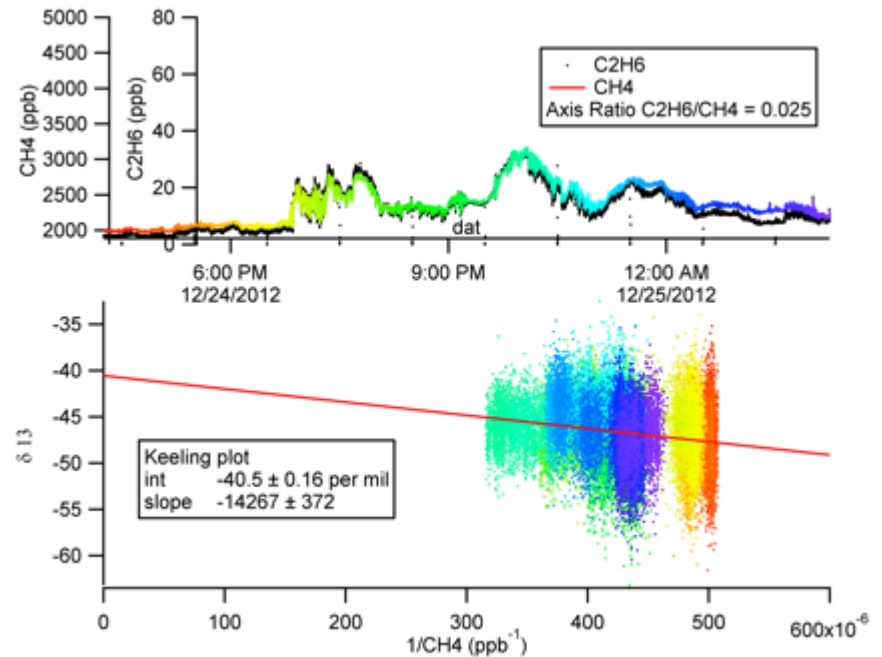
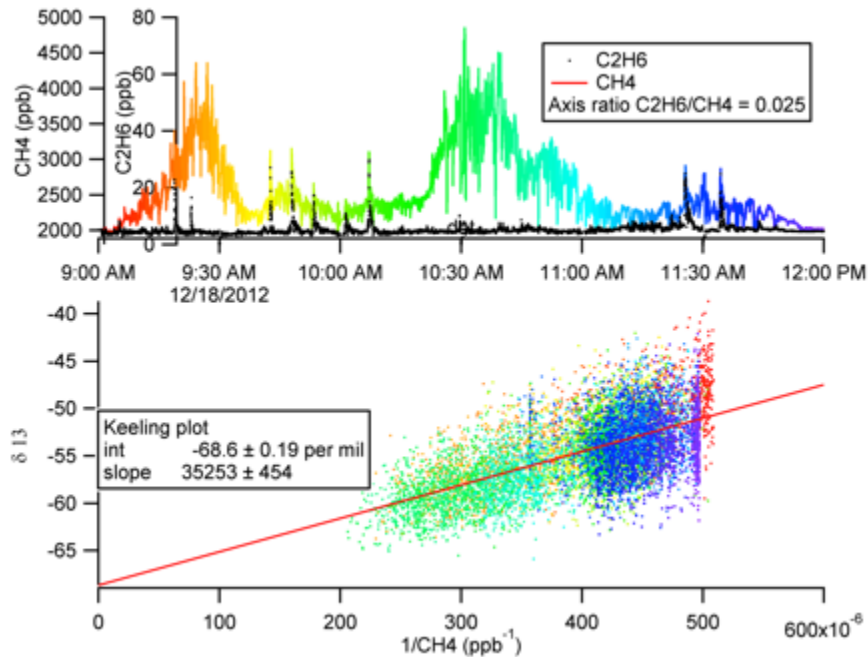
Arts and Sciences
Building Rooftop



Are Methane and Ethane “Isotopologues” of Natural Gas?

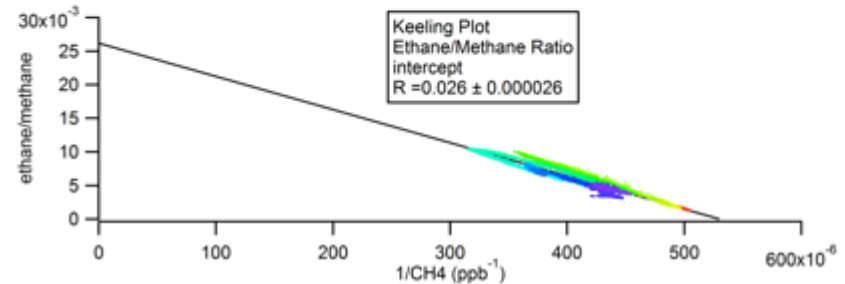
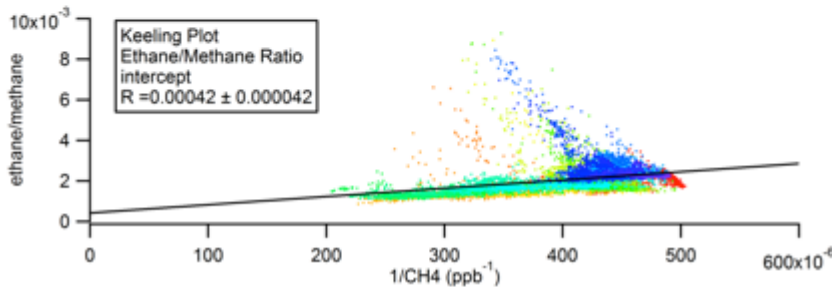
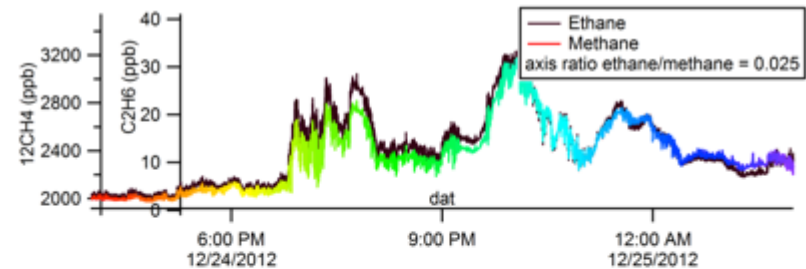
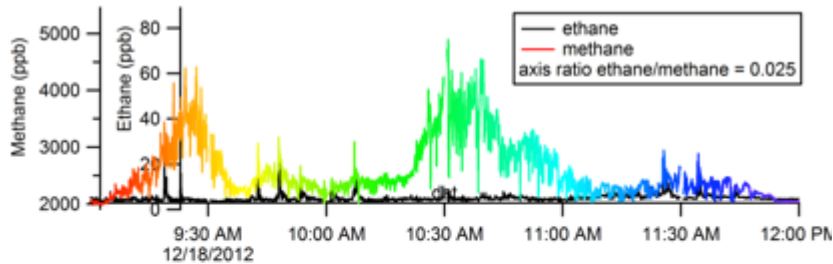
- Natural gas in pipeline is typically 97% methane and 3% ethane, hence ethane is comparable to $^{13}\text{CH}_4$ (1.1%)
- But “Isotopic abundance” of ethane varies greatly by end member:
 - From 2 to 10% in various gas wells (-300 to +3000 per mil!)
 - Fairly constant and well known in distribution systems
 - Very low from most biogenic sources (<0.2% or -1000 per mil)
- Fractionation occurs – LNG for example

Using Standard Isotopes for Source Attribution



- Left panel shows methane with biogenic origin
- Right panel shows methane with thermogenic origin
- But this is a hard measurement...

Using Unconventional “Isotopes” for Source Attribution



- Left panel shows natural gas with biogenic origin
- Right panel shows natural gas with thermogenic origin
- This is a very easy measurement thanks to ethane's large variation by source

Aircraft Results

