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

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Methane and Ethane

Wind from SSW
160°
5 m/s
Biogenic vs Thermogenic Methane

![Graphs showing biogenic and thermogenic methane emissions.](image)
Aerodyne’s Ethane Mini: Direct Absorption

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

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.

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 CH$_4$ sources?
Biogenic Sources

Graphs showing ethane and methane concentrations over time for compost, cows, and landfill. The graphs indicate peaks in ethane and methane at specific times, with the data spanning from 07:48 to 07:50 on 3/29/2013. The right graph shows a comparison of ethane concentration against methane concentration, with lines indicating 20% and 0% thresholds.
Oil and Gas Sources

![Graphs showing ethane and methane levels over time with different markers indicating different sources.]

- **Bridgeport**: gas processing
- **South of Decatur**: well pads
- **North of DFW**:
Plume Origins

Bridgeport Processing Facility

Producing Wells South of Decatur

More wells near Rhome
Mapped Ethane to Methane Ratios

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

Legend:
- 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.
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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