REACTIVE ORGANICS FROM OIL AND GAS COMBUSTION SOURCES

Seth Lyman, PhD
Makenzie Holmes
Huy Tran, PhD
Winter Ozone is a Frequent Problem
In the Uinta Basin

[Bar chart showing daily max 8-hour ozone (ppb) with years from 2009 to 2018, with stations labeled Ouray, Roosevelt, Vernal, Fruitland, and Rangely, and a dashed line indicating a 70 ppb standard.]
Winter Ozone Occurs When Snow Cover Facilitates Temperature Inversions
Oil and Gas Development is the Primary Source of Ozone-forming Emissions
Out-of-the-box Emissions Inventories Fail to Simulate Enough Winter Ozone in Photochemical Models

Matichuk et al. (2017) produced high ozone in their model only by dramatically increasing organic compound emissions
Emissions Inventories Simulate Total VOC in the Right Ballpark, but Reactive VOC are Much Too Low
Portable Sampling Stations Allow for Snapshot of VOC Composition, Distribution

- Collection of silonite-coated canister samples for C2-C10 hydrocarbons and light alcohols
- Collection of DNPH cartridges for carbonyls
- Samples were analyzed to identify 73 separate organic compounds
- Air samples collected over 6 hr periods in the day or night
- Sampling, data collection controlled by a Rasbery Pi
Sampling Station Deployments Show Distribution Of Organics Across the Uinta Basin
Several Distinct Patterns Emerged Across 13 Deployments in 2019 and 2020
Samples Collected in Areas with More Oil Wells Had a Higher Percentage of Alkenes + Acetylene

Percent by mass

Number of oil wells within 10 km radius

0-2
3-12
13-20
21-48
49-80
81-120
121-247
248-487
488-636
637-794

Carboxyls
Alcohols
Aromatics
Alkenes + Acetylene
Alkanes
Alkenes + acetylene Responsible for Large Portion of Ozone Reactivity in Oil-Producing Areas

Percent by contribution to ozone production

Number of oil wells within 10 km radius
Compound Ratios Indicate Lean-burn Natural Gas Engines as Most Important Source of Alkenes+acetylene

- Previous studies show very low emissions from non-combustion sources
- Observed very high propylene:ethylene and ethylene:acetylene ratios indicate:
  - Raw natural gas, rather than gasoline or diesel, as the fuel source
  - Cool, lean-burn combustion conditions
Official Emissions Inventory Also Shows Higher Percentage of Alkenes from Facilities with Engines

Facility locations colored by percentage of emissions comprised of alkenes+acetylene
Inventoried Alkene Emissions are Much Lower Than Ambient Air Measurements
Conclusions

1. Alkenes are an important contributor to ozone reactivity of organics in an oil producing area
2. Most important source of alkenes appears to be raw gas-fueled lean-burn engines
3. Official inventory appears to vastly underestimate alkene emissions.

Lean-burn creates less NO$_x$ and more reactive organics, while rich-burn creates more NO$_x$ and fewer reactive organics. Which mode is best for the airshed?
Thank You

Funding provided by:
- Utah Division of Air Quality
- Uintah Impact Mitigation Special Service District
- Utah Legislature
- Anadarko Petroleum Corporation (funding for student internships)

Site access provided by the Ute Indian Tribe

seth.lyman@usu.edu binghamresearch.usu.edu