Developing a Fuel-Based Inventory of Oil and Gas Emissions

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Oil & Gas Regions Near Many Projected Ozone Nonattainment Areas

High wintertime ozone

Map showing shale oil & gas plays and nonattainment areas.
High Wintertime Ozone in Uinta Basin, Utah

O&G NO\textsubscript{x} decreased by $\sim4x$, VOC increased by $\sim2x$

Ahmadov et al. (Atmos. Chem. Phys. 2015)
Recent studies suggest ozone in Denver Front Range is

- **Sensitive to NO\textsubscript{x} emissions**
  

- **Transitioning to NO\textsubscript{x} Sensitivity**
  
Increasing NO$_2$ Observed over Some O&G Regions from Space

Duncan et al. (J. Geophys. Res. 2016)

Increasing over W. Texas and North Dakota (2005-14)
Research Objectives

(1) Construct a fuel-based inventory of oil & gas emissions
   - Estimate $\text{NO}_x$ from combustion-related emissions
   - Compare with NEI 2014 and EPA Oil and Gas Tool

(2) Compare with “top-down” emissions derived from three NOAA-led field measurement campaigns
   - Uinta Basin Wintertime Ozone Study (UBWOS) in 2012-13
   - Southeast Nexus Study (SENEX) in 2013
   - Shale Oil & Natural Gas Nexus Study (SONGNEX) in 2015
Fuel-Based Estimate of Oil & Gas NO\textsubscript{x} Emissions

\[ \text{Emissions} = \text{Activity} \ (\text{kg CO}_2) \times \text{Emission Factor} \ (\text{g/kg CO}_2) \]

**Exploration**
- e.g. drilling, fracturing, trucking
- Off-road diesel fuel (EIA)

**Production**
- e.g. dehydrators, heaters, compressors
- NG on-site fuel (EIA)

**NG Processing Plants**
- CO\textsubscript{2} emissions reported at facility level (EPA)

**EPA Oil & Gas Tool**
- Literature Review

**Continuous Emissions Monitoring (CEMS)**
Oil & Gas Diesel Fuel Use Scales with Drilling Activity

- Texas
- Plains
- Mountain West
- Marcellus

O&G Diesel Use ($10^6$ L) vs. Drilling Rigs (Weekly Count)
Oil & Gas Natural Gas Use Scales with Natural Gas Production

- Texas
- Plains
- Mountain West
- Marcellus

O&G Natural Gas Use (10^12 L)

Natural Gas Production (10^12 L)
Spatial Surrogates to Downscale State-Level Fuel Data
CO₂ Emission Factors for Major Oil & Gas Engine Sources

Self-consistent with state-level EIA fuel use data
Examples of Gridded Fuel-Based Oil & Gas NO$_x$ Inventory
Comparison of Top-Down and Bottom-Up Emission Inventories

NO\textsubscript{x} (metric t d\textsuperscript{-1})

- NEI 2014
- O\&G Tool 2014
- Fuel-Based

Haynesville TX/LA
Uinta UT
NE Marcellus PA
Fayetteville AK
NOAA-led Campaigns Available to Constrain Oil & Gas Emissions

- SONGNEX 2015
- SENEX 2013
- UBWOS 2012-13

Locations:
- Uinta
- Fayetteville
- Haynesville

Regions:
- Northeast Marcellus
Top-Down Methane Emissions Derived from Aircraft

Example of CH$_4$ measurements in flights over Haynesville Basin

Peischl et al. (J. Geophys. Res. 2015)
Simultaneous Aircraft Measurements of NO$_y$ (Haynesville)

SENEX 2013

Four research flights over Haynesville Basin

SONGNEX 2015
Consistent Enhancements in NO\textsubscript{y} and CH\textsubscript{4} Observed (Haynesville)

SENEX 2013

SONGNEX 2015
Correlation of NO$_y$/CH$_4$ Also Observed Across Many O&G Basins

NOAA Flights cover 7 basins across U.S.

$R^2 = 0.68$
Comparison of Top-Down and Bottom-Up Emission Inventories

NEI 2014

O&G Tool 2014

Top-Down

Fuel-Based

NOx (metric t d⁻¹)

Haynesville TX/LA

Uinta UT

NE Marcellus PA

Fayetteville AK
Summary

- Developed fuel-based inventory for oil & gas NO$_x$ emissions
  - Biggest differences between fuel-based inventory and NEI in activity

- Bottom-up NO$_x$ emissions evaluated with “top-down” emissions
  - NO$_y$/CH$_4$ correlation consistently observed over oil and gas basins
  - Evidence for overestimate in oil & gas NO$_x$ in NEI, but varies by basin
  - Fuel-based inventory consistent with observations