

Emissions from upstream oil and gas operations in the United States: Key questions for health assessments

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Multiple types of air pollutant emissions associated with oil and gas production and processing

- Emissions of ozone and particulate matter (PM) precursors (Volatile organic compounds (VOCs), oxides of nitrogen (NO_x), others)
- Air toxics (benzene, others)
- Greenhouse gases (carbon dioxide, methane)



Unresolved issues in VOC, NO_x and GHG emissions along oil and gas supply chains

- Understanding temporal patterns of emissions
- Understanding compositions of emissions
- Understanding of near-release chemical transformations

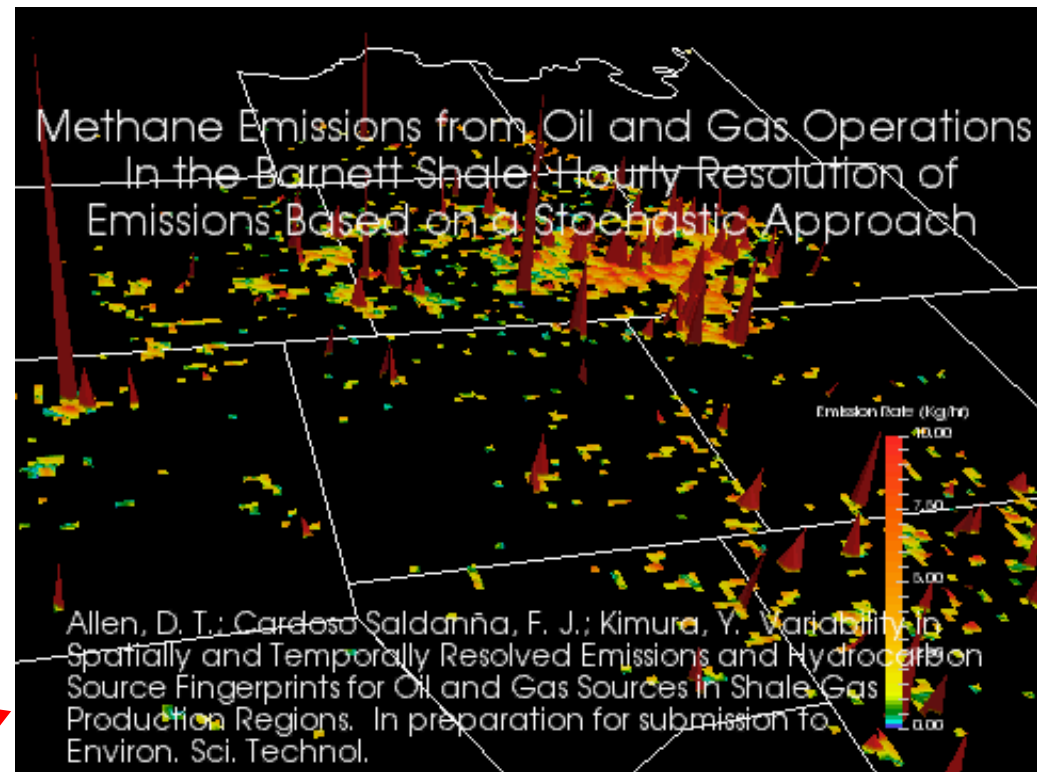
Understanding temporal patterns of emissions

Most emission inventories are annual emission estimates and do not capture temporal variations in emissions

- Emissions vary over the multi-year life of a well
- Emissions vary on hourly, daily and weekly time scales, even at single stages of a well's life



Estimates of hourly variability in emissions: Case of methane

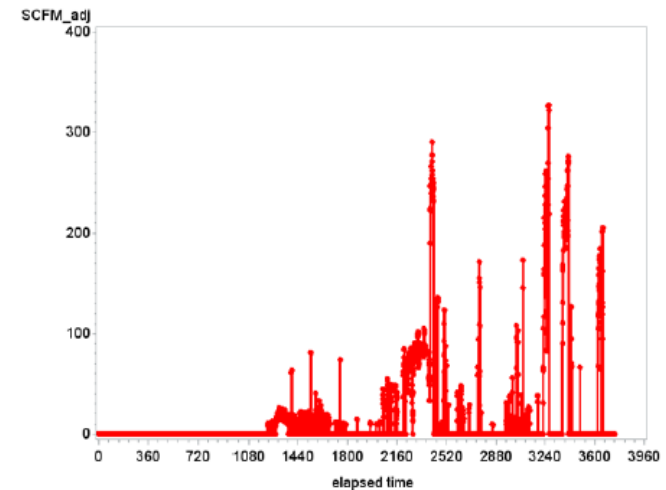


Emissions vary over the multi-year life of a well

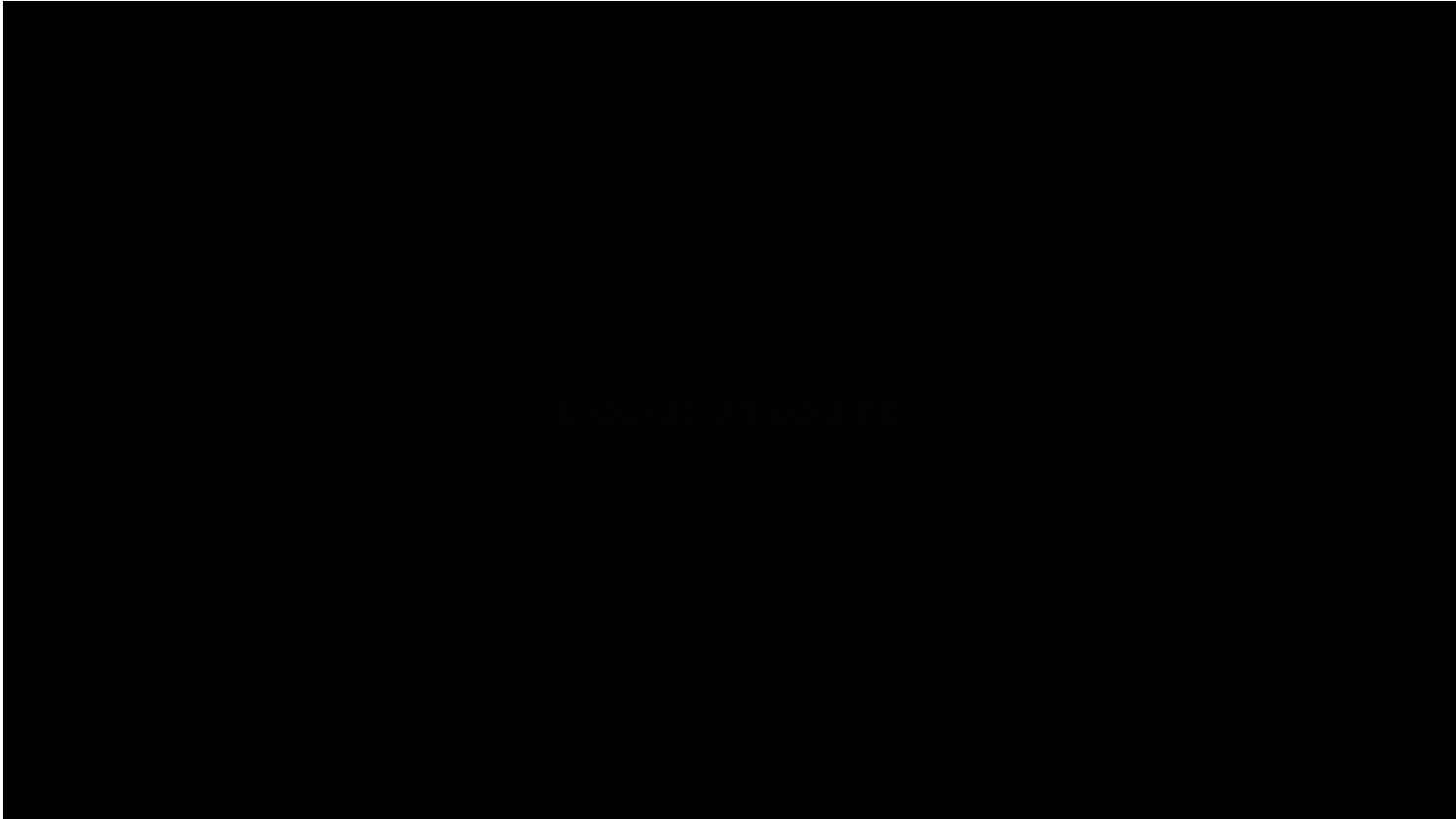
Drilling (weeks to months) → Completion (days to weeks) → Initial production (months to years) → late stage production (months to years)

Well completion flowback

Total gas flow as emissions over first 3 days of a completion flowback



Emissions vary on hourly, daily and weekly time scales, even at single stages of a well's life

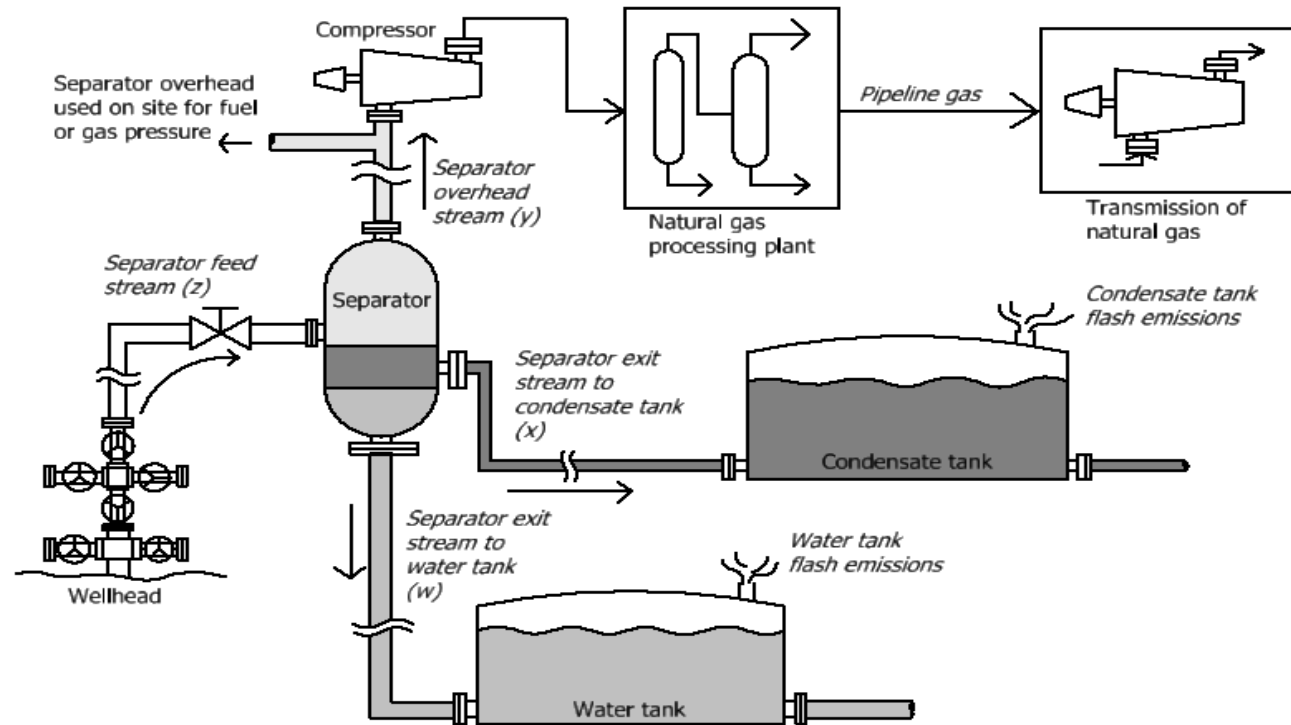


Emissions from a single liquid unloading, lasting from minutes to hours, can have a flow rate equivalent to thousands of wells in routine operations

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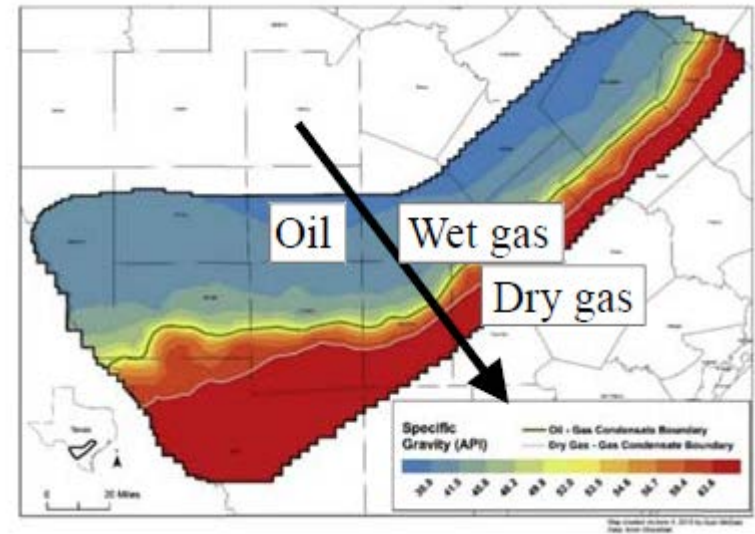
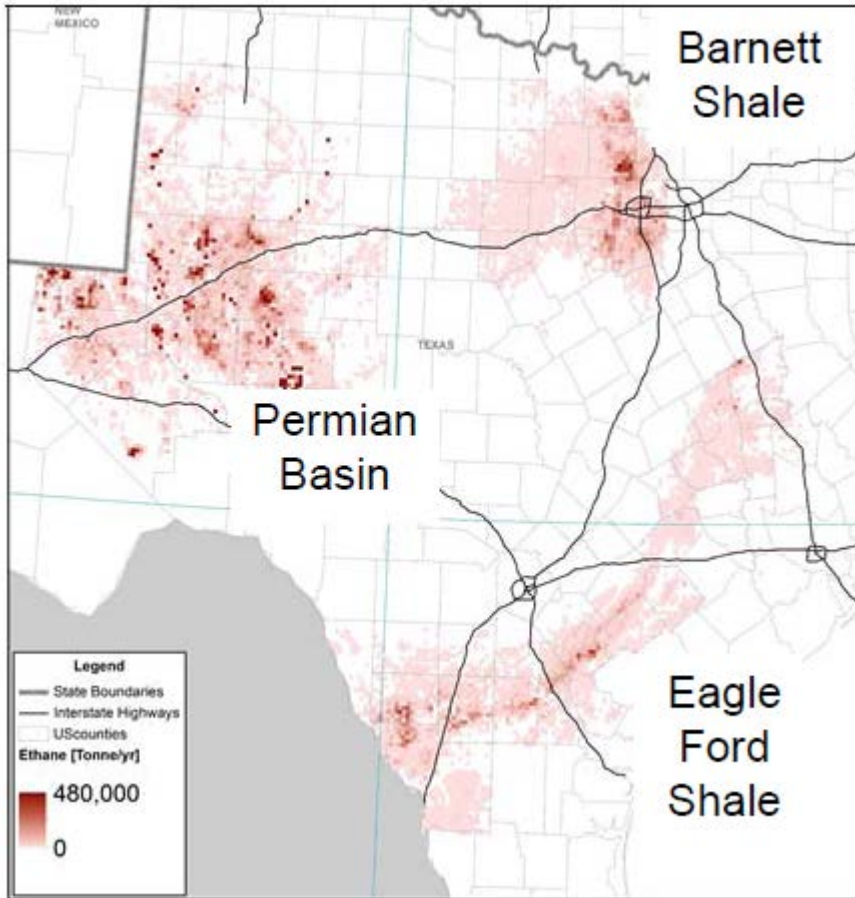
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Understanding compositions of emissions



Emission compositions vary across a well site and vary depending on point in the supply chain; also vary temporally

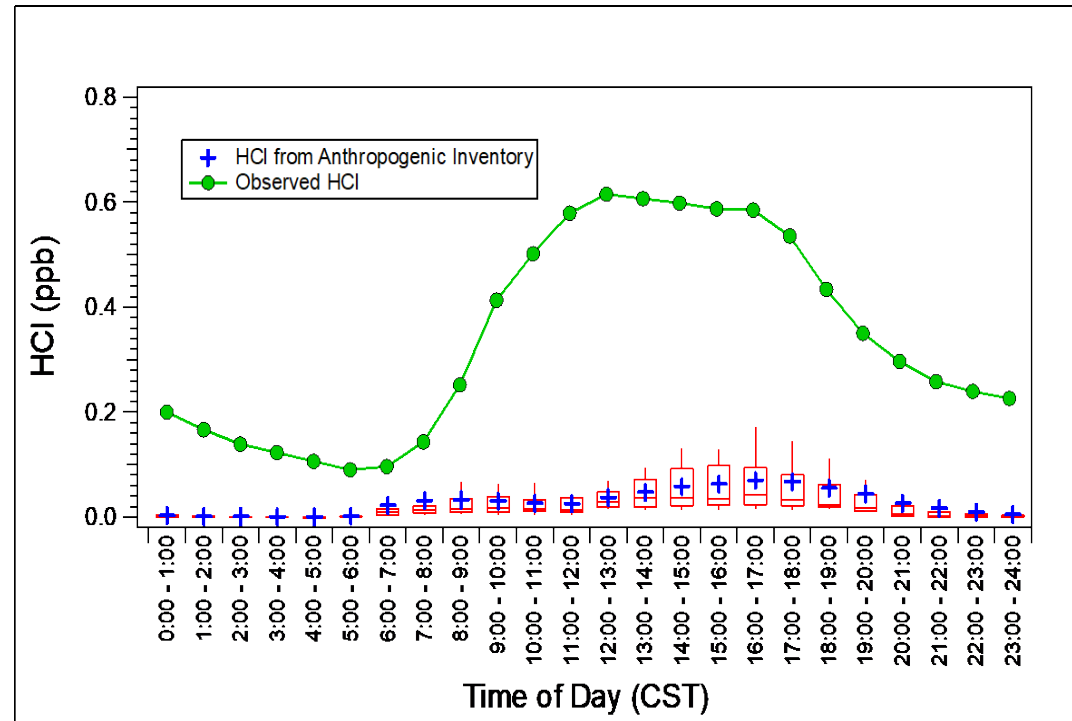
Understanding compositions of emissions



Compositions vary between regions and within regions

Understanding compositions of emissions

- Some emission compositions are well understood based on compositions of oil, condensate, gas, fracking fluids, and other data
- Some compositions are not well understood (case study of Barnett Shale field study)

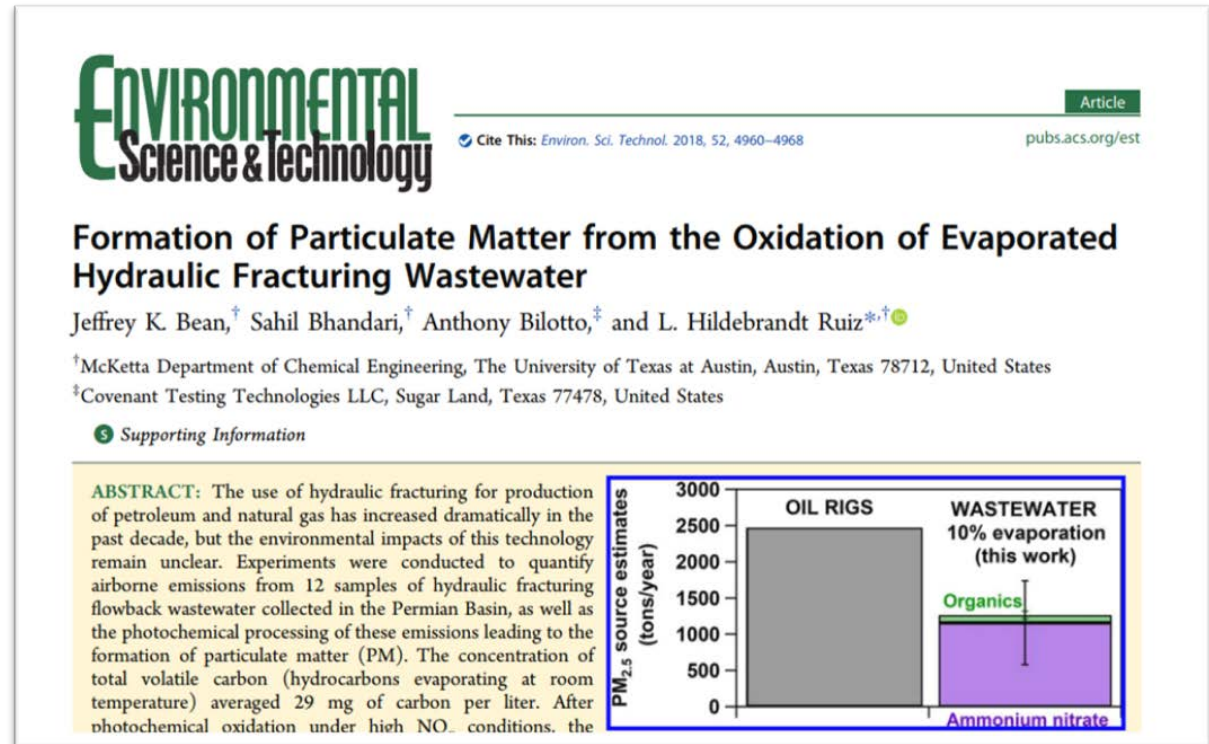


Unresolved issues in VOC, NO_x and GHG emissions along oil and gas supply chains

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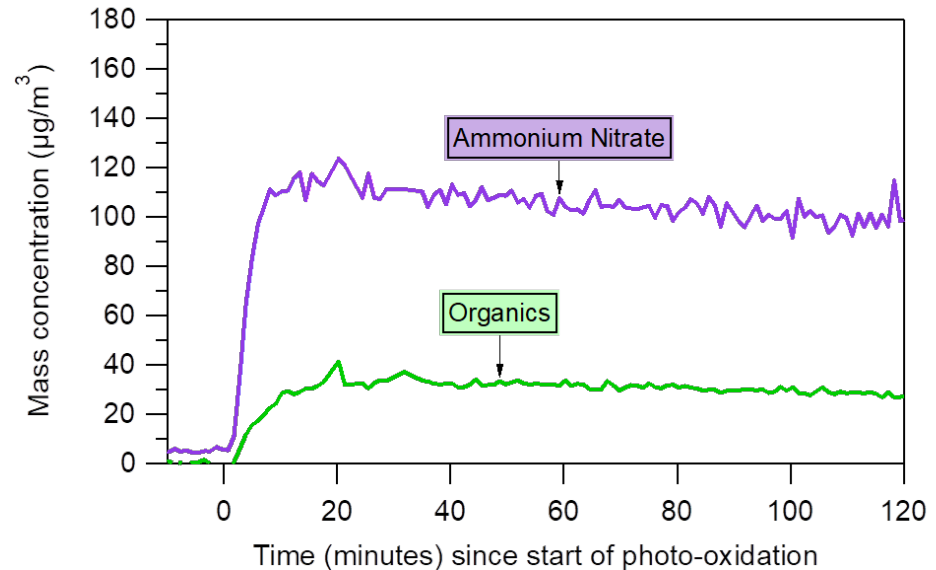
Understanding of near-release chemical transformations

- Case study of Secondary Organic and Inorganic Aerosol formation during completion flowbacks



Particulate matter formation from flowback water evaporation

- Collected 12 samples of flowback wastewater from separators and storage tanks in the Permian Basin
- Evaporated aliquots into environmental chamber; added oxidant precursors and NO_x ; observed formation of particulate matter



HNO₃ from added
NO_x + NH₄ from
wastewater →
NH₄NO₃

VOCs from
wastewater + added
oxidants → lower
volatility OC →
secondary organic PM

Unresolved issues in VOC, NOx and GHG emissions along oil and gas supply chains

Issues

- Understanding temporal patterns of emissions
- Understanding compositions of emissions
- Understanding of near-release chemical transformations

Recommendations

- Field campaigns for multiple stages in well life
 - Select sampling region carefully, based on target compounds of interest
 - Coordinate with operators to obtain activity data
 - Compare observations with time and location specific inventories
- Laboratory studies using field collected samples of well fluids
 - Samples must be collected carefully