RESEARCH ON LOCAL AND REGIONAL AIR QUALITY IMPACTS OF OIL AND NATURAL GAS DEVELOPMENT

NETL
NATIONAL ENERGY TECHNOLOGY LABORATORY

BACKGROUND

Unconventional oil and gas (UOG) activities generate emissions of various compounds: nitrogen oxides (NO_X), volatile organic compounds (VOCs), and particulate matter (PM) from engines used for drilling and hydraulic fracturing; methane, carbon dioxide, and VOCs from venting, flaring, and fugitive emissions of natural gas; methane and VOCs from produced water handling and on-site gas processing; suspension of PM from vehicle travel on gravel roads. Additionally, formation of secondary pollutants (VOCs, PM, ozone) from the primary pollutants is possible. UOG operators seek to reduce emissions and fugitive releases of gas as per regulatory requirements as well as to prevent loss of product. Because emissions characteristic of specific UOG activities have profiles discernible from each other and from a baseline, an assessment of emissions trends can be used as a tool to infer and inform UOG performance. By providing a complete understanding of the impacts of oil and gas development on regional air quality, the U. S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) can ensure that oil and gas development proceeds at a rate that protects the environment while ensuring an adequate domestic supply.

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GOAL

The goals of the NETL research effort aimed at improving the assessment of impacts to air quality from oil and gas exploration and production activities are: (1) use NETL's stationary ambient air monitoring laboratory, vehicle-based methane plume surveying equipment, and infrared cameras to conduct targeted on-site measurements of emissions from oil and gas production activities and (2) use collected data in numerical models to understand emission and dispersion rates to assess impacts to local and regional air quality and to compare emissions trends under various operational scenarios.

OBJECTIVES

The objectives of this NETL research include:

1. Process data from prior year monitoring to evaluate trends in emissions with respect to operator activity
2. Continue with new ambient air monitoring opportunities at unconventional oil and gas (UOG) field sites
3. Evaluate use of atmospheric tracers (for example, ethane) to track environmental performance of UOG operations
4. Evaluate emissions tradeoffs for natural gas injection for enhanced oil recovery (EOR) versus flaring. Operational scenarios will be evaluated for potential natural gas-EOR systems, which will be used to inform future-year field efforts for emissions monitoring in the Bakken shale oil play

Collection and analysis of field-based air quality data sets allows identification of potential opportunities for emissions mitigation based on observed trends in measurements.

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NETL CAPABILITIES

MOBILE AIR MONITORING LABORATORY

A government-owned trailer was modified to serve as an autonomous air emissions monitoring laboratory. The temperature controlled laboratory space houses several monitoring instruments that are capable of transmitting collected data back to the NETL site via satellite. Instruments include:

- Picarro G2112-i CRDS analyzer to measure methane, carbon dioxide, and carbon isotopes in methane and carbon dioxide
- Thermo Fisher Tapered Element Oscillating Microbalance (TEOM) to measure PM_{10} and $PM_{2.5}$
- Perkin Elmer Ozone Precursor Analyzer (a GC-FID with sample introduction via thermal desorption) to measure volatile organic compounds (VOCs)
- Teledyne-Air Pollution Instruments gaseous monitors for NO_X and O_3
- R. M. Young and Davis Instruments meteorological sensors to measure temperature, humidity, wind speed, wind direction, and other meteorological variables.

METHANE PLUME SURVEYING EQUIPMENT

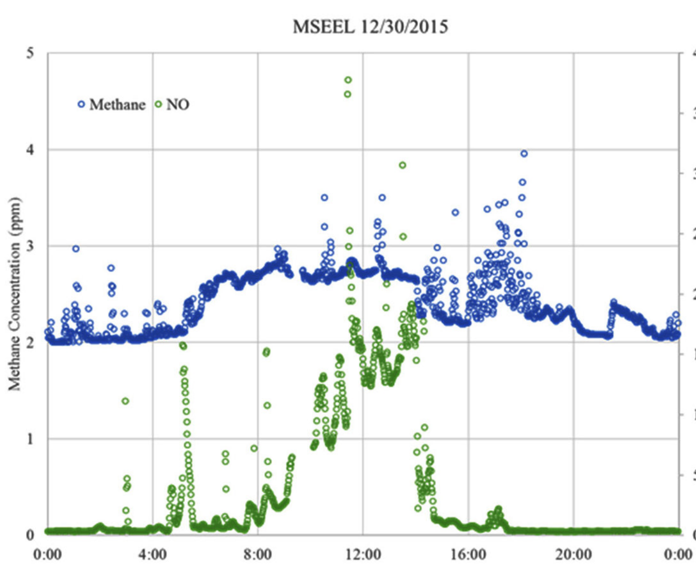
A Picarro G2203 methane and acetylene CRDS analyzer measures fugitive methane emissions via acetylene tracer measurement. Mobile mapping of concentration data with integrated global positioning system (GPS) yields spatial representation of methane plumes.

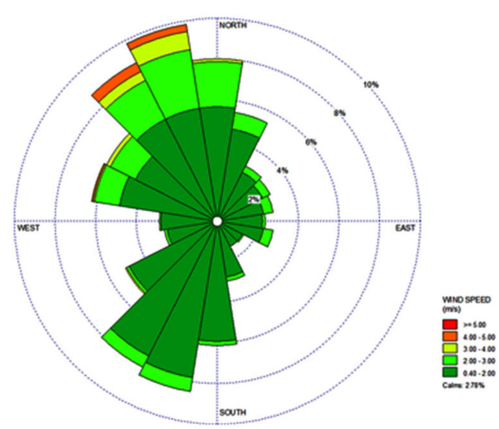
INFRARED CAMERAS

Two FLIR GF320 infrared cameras record still shots or video of well pad emissions for qualitative interpretation of emission sources.

BENEFITS

Ambient air monitoring at UGO sites with high time resolution will provide datasets that will allow characterization of the impact to air quality from the on-site activities as well as information to assess the emissions performance. High time resolution data is required as emissions events tend to be sporadic and short-lived; daily- or multi-daily averaged data will not provide the resolution needed to identify peak events. Concentration measurements of multiple components (methane, carbon dioxide, volatile organic compounds, nitrogen oxides, etc.) are needed to distinguish individual emissions sources, as each have specific emissions profiles that cannot be determined with only one pollutant measurement (i.e., methane). The results of this research are rich, unique datasets that are not otherwise available and allow NETL to conduct source-receptor modeling, dispersion modeling, and risk assessments that characterize well pad activities by air quality parameters.





Using time series analysis and wind roses to find and characterize plume events

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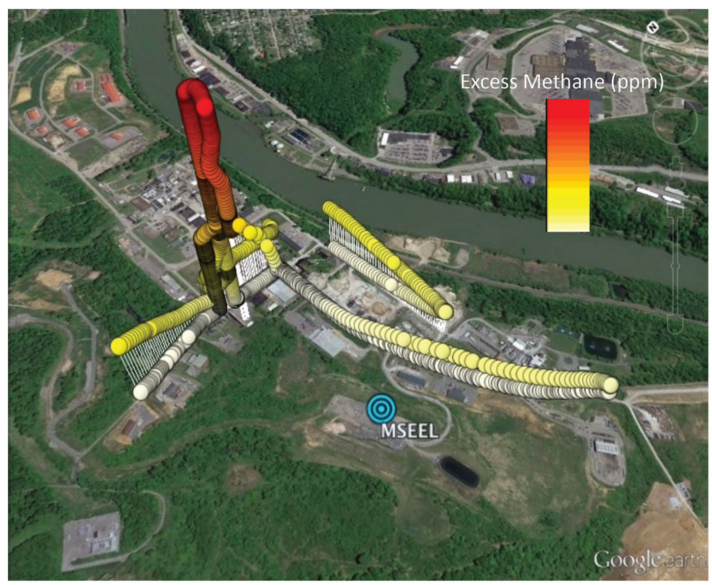
ACCOMPLISHMENTS

NETL's Mobile Air Monitoring Laboratory has been deployed to several UOG sites, the most recent being the Marcellus Shale Energy Environmental Laboratory (MSEEL) in Morgantown, WV. Analysis of the data continues, but preliminary results show that concentrations of tracer species like ethane can be used to distinguish natural gas-related emissions from other emissions sources, like diesel engines. Additionally, evaluation of carbon isotopes can identify the methane as biogenic or thermogenic, allowing a distinction between background methane and on-site methane emissions sources. Collected data show that the flowback period had the greatest impact to methane and VOCs concentrations at the MSEEL site. Analysis of isotopic signature and wind rose support the conclusion that peak concentrations of methane and VOCs observed during flowback are from activity on the well pad and not from other off-site sources. However, polar and scatter plots of alkanes using data collected during the entire monitoring period provide evidence of influence of off-site natural gas emissions sources.

Mobile mapping of methane concentrations at the MSEEL site has successfully managed to identify clear evolution of emissions of methane throughout development of the wells, which are located within a complex urban environment. Emissions attributed to combustion engines were highest during drilling and production stages, with several methane-enriched plumes observed during flow-back and a single notable plume observed during the production stage. Off-site methane emissions sources (flooded storm drains, a coal-fired power plant, and various other small sources) were located and identified such that their potential to impact on-site concentration measurements can be quantified.

Passive monitoring of nitrogen-containing compounds at multiple up-and down-wind locations at the MSEEL site quantified total additional dry reactive nitrogen deposition around the well pad and provided the first approximation of nitrogen loadings that are attributable to individual UOG well pad development phases. In this study, it was determined that access road traffic is a large source of NO_x to areas near well pads. It was also determined that well pad activities affect local ammonia concentration dynamics and are more likely to occur during phases where large diesel engines are used. Additionally, isotope source apportionment modeling was used to determine NO_x emission source apportionments to nitrogen deposition. At the MSEEL site, the operator utilized the industry's current best management practices, making this study an example of a best-case scenario for nitrogen deposition surrounding a well pad.



Results of a methane survey conducted during flowback operations at the Marcellus Shale Energy Environmental Laboratory (MSEEL), an active shale gas development site in Morgantown, West Virginia. High methane concentrations were observed downwind of the well pad. Data were used to estimate methane emission rate.

Research Partners

West Virginia University
University of Pittsburgh
St. Francis Xavier University
The Energy and Environmental Research Center (EERC) at the University of North Dakota in Grand Forks, ND
Natural Resources Canada's (NRCan) CanmetENERGY
Geologic Survey of Canada

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