[PS]Atmospheric Gas Concentrations During an Unconventional Oil and Gas Recovery Operation at the MSEEL Test Site, West Virginia*

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Abstract

The Marcellus Shale Energy and Environment Laboratory (MSEEL) in West Virginia provides a unique opportunity in the field of unconventional energy research. By studying near-surface atmospheric chemistry over several phases of a hydraulic fracturing event, the project will help evaluate the impact of current practices, as well as new techniques and mitigation technologies. A total of 10 mobile surveys were conducted around the MSEEL site that contains 3 test wells (1 science well and 2 natural gas producing wells) and over several miles of nearby regional routes. Our surveying technique involved using a vehicle-mounted Los Gatos Research Ultraportable Methane/Acetylene Analyzer that provided geo-located measurements of methane (CH_4) and carbon dioxide (CO_2). The ratios of super-ambient concentrations of CO_2 and CH_4 were used to separate drilling- and fracturing-related observations from the natural background concentrations over the various well pad developmental stages. We found that regional background methane concentrations were elevated in all surveys, with a mean concentration of 2.699ppm (n = 98369), which simply reflected the mix of anthropogenic and natural CH_4 sources in this riverine urban location. Over time and through successive stages of well development, we noted a progressive rise in the occurrence of enriched methane in the vicinity of the developed wells. While there was a moderate degree of variability over time, we did observe a higher occurrence of CH_4-enriched observations during and after production began at the test site (~25% of measurements within 500 meters of the test wells) compared to the baseline surveys (>10% of measurements). This change was expected, as we anticipated some level of increased emissions from the well pads as production began. However, we did not expect the rise to be so noticeable. The results of this study show that there is a statistically significant increase in the occurrence of enriched methane values in the vicinity of the well locations when we compare pre-production to postproduction surveys, and that pre-existing methane sources in the immediate vicinity must be accounted for when assessing environmental impacts.

Reference Cited

Allen, D.T., V.M. Torres, J. Thomas, D.W. Sullivan, M. Harrison, A. Hendler, S.C. Herndon, C.E. Kolb, M.P. Fraser, A.D. Hill, B.K. Lamb, J. Miskimins, R.F. Sawyer, and J.H. Seinfeld, 2013, Measurements of Methane Emissions at Natural Gas Production Sites in the United States: Proceedings of the National Academy of Sciences, v. 110/44, p. 17768-17773.

ATMOSPHERIC GAS CONCENTRATIONS DURING AN UNCONVENTIONAL OIL AND GAS RECOVERY OPERATION AT THE MSEEL TEST SITE, WEST VIRGINIA

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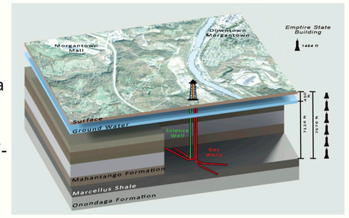
Introduction

The Marcellus Shale Energy and Environment Laboratory (MSEEL) in West Virginia provides a unique opportunity to measure the effects of hydraulic fracturing in an urban environment. The site consists of 2 producing wells and 1 science well, which was used to provide detailed subsurface data (right).

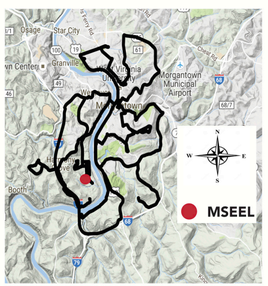


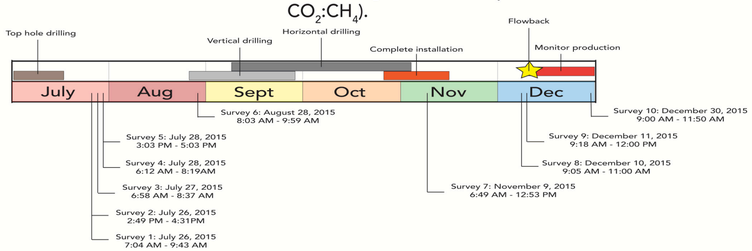
In this study, we seek to analyze atmopsheric gas measurements and observe temporal and spatial trends at the MSEEL site utilizing a mobile surveying approach. We hypothesize that the MSEEL site will be associated with episodic emissions, with peaks at flowback and sustained emissions through production. We also suspect that MSEEL emissions can be detected above the natural and urban variations.

Methods

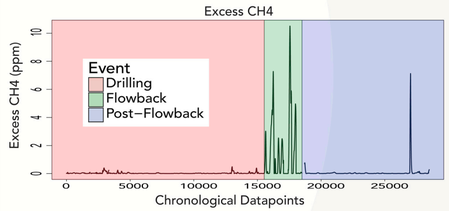
The mobile surveying method consists of a vehicle-mounted LGR Ultra-Portable Methane/Acetylene analyzer. Tubing runs from the front of the vehicle to the analyzer located in the cab. Atmopsheric gases were sampled for CO_2 and CH_4 at a 1 Hz frequency.

A total of 10 mobile surveys were performed from July 26th to December 30th, 2015 for a total amount of 99,376 geo-located data-points. The general survey route relative to the MSEEL site is outlined in the figure to the left. A timeline of all hydraulic fracturing events relative to timing of surveys is outlined in bottom figure. Mean CH_4 and CO_2 concentrations were 2.699 (± 0.010) ppm and 439.4 (± 0.3) ppm, respectively, for the entirety of all surveys (95% CI). In order to distinguish between natural/urban variations and MSEEL emissions, we subtracted ambient background levels from our dataset to obtain excess concentrations. Ratios of excess CH_4 to excess CO_2 were used to further distinguish between potential sources (E-ratio CO_2:CH_4).

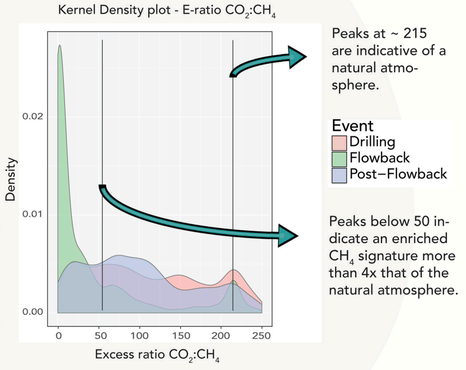


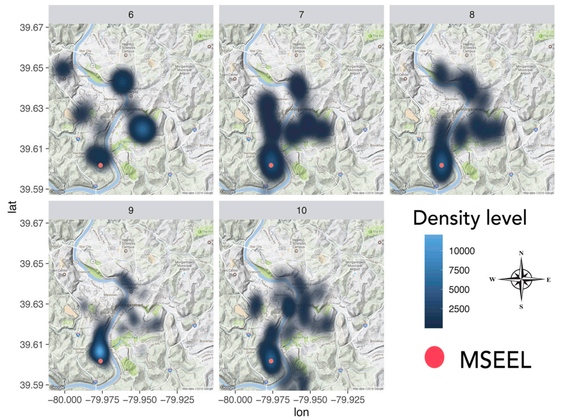


MSEEL Emissions



- Datapoints were binned spatially to within 1 km of the MSEEL site.
- This subset was divied up into three separate events: drilling (Surveys 1 - 8), flowback (Survey 9) and post-production (Survey 10).
- Methane emissions from the MSEEL site varied over the 10 surveys, but showed distinct peaks during flowback (top figure).
- Drilling emissions were episodic, and ranged from nearly non-existent to mildly above ambient levels.
- Depletions in excess CO_2:excess CH_4 below 50 are indicative of a CH_4 concentration more than 4 times that of the natural atmosphere.
- Flowback showed a significant density peak in excess CO_2: excess CH_4 approaching 0, which is highly enriched in CH_4 relative to the natural atmopshere.

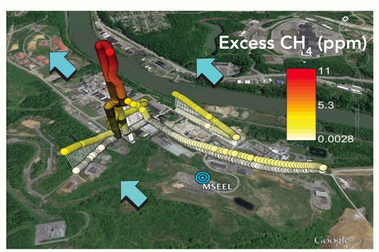




- Southward winds for Survey 6 and 7. Northward winds for Survey 8-10.
- Data was filtered for excess CO_2:excess CH_4 values below 50 and plotted via density contour method (left figure).
- Sporadic plumes are evident throughout the surveys.
- Density plumes in the MSEEL vicinity are consistent throughout Surveys 6 - 10.
- The greatest density peak is observed during flowback (Survey 9).

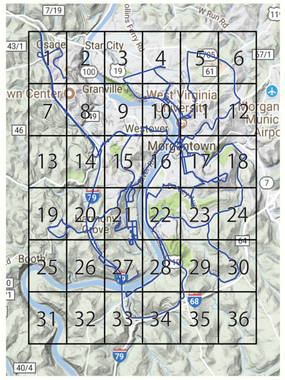
Volume Quantification of Flowback

- Volume output of CH_4 during flowback was estimated from largest observable downwind plume during flowback (right figure) via Inverse Gaussian Plume Dispersion model.
- Output was estimated at **1028.3 (+/- 889.2) g/min CH_4** during largest flowback plume.
- Related study by Allen et al. (2015) saw flowback volume output ranging from **2970 g/min** to **5 g/min CH_4**.



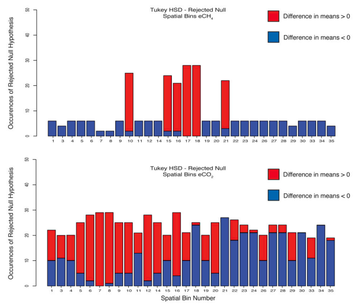
MSEEL Within Urban Complexity

A)



- Urban environments such as Morgantown present challenges for CH_4 source attribution.
- There are a number of potential CH_4 sources that exist in this riverine urban location, both from natural (eg. Monongahela River) and anthropogenic sources (eg. sewage treatment plants).
- The elevated CH_4 concentrations observed thoughout the surveys suggest that there may be large regional CH_4 contributions from various sources within the Morgantown region.
- The largest CH_4 concentrations were detected near a flooded storm drain in grid 17 (over 300 ppm CH_4).

B)



- We binned data spatially (Figure A), and plotted the occurences of rejected null hypothesis for both eCO_2 and eCH_4 via Tukey HSD test (Figure B).
- The MSEEL cell was one of 6 associated with significantly elevated eCH_4 concentrations.
- Cells characterized as urban environments were predominantly associated with elevated CO_2 concentrations
- Not all natural and urban sources of CH_4 and CO_2 have been accounted for.

Future Work

- The MSEEL site continues to be used in studies spanning a variety of scientific disciplines. Future work will likely involve more intensive surveying expeditions going forward, as emissions will continue during production.
- Future studies will involve on-pad testing, where the addition of analyzed gas species (e.g. ethane, hydrogen sulfide) would be useful for identifying emission sources.
- Additional plume analyses would be beneficial, supported by better anemometer and meteorological measurements.

References

Allen, David T., et al. "Measurements of methane emissions at natural gas production sites in the United States." Proceedings of the National Academy of Sciences 110.44 (2013): 17768-17773.

Special Thanks

We'd like to thank MSEEL and associated parties for the opportunity to perform this research, and for the help and guidance along the way.
We'd strongly recommend visiting their website for more information on related research, as well as for additional background info: mseel.org