Impacts of Fracking on Local Ozone Pollution in DFW Area

Mahdi Ahmadi, University of North Texas
Department of Mechanical and Energy Engineering. Advisor: Dr. Kuruvilla John

A green light to greatness.

TOULOUSE GRADUATE SCHOOL UNT

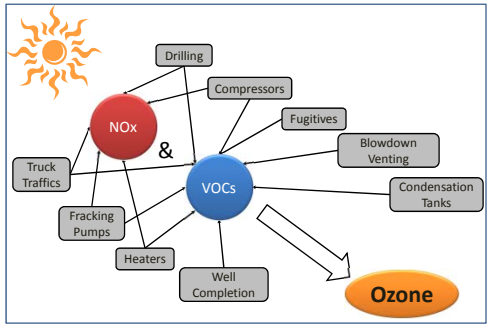
UNT Graduate Exhibition 2014

Abstract

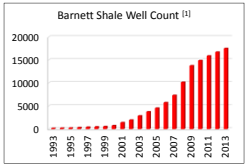
Citizens are being increasingly concerned about the local air pollution of natural gas fracking activities. An advanced statistical method (Kolmogorov-Zurbenko filter) is applied to the ozone time-series data measured by sixteen state monitoring sites over the course of fourteen years in Dallas-Fort Worth area. According to the results, sites surrounded by fracturing activities show worse long-term trends in ozone reduction than those located farther from gas wells. Also the findings show that the uneven spatial distribution of gas wells has skewed the spatial extent of local ozone problem. This study, for the first time, is demonstrating the long-term negative effects of fracking activities on local ozone pollution.

Background

Ozone is one of the criteria pollutants with negative health effects on humans. Ground level ozone is formed by photochemical reactions of nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the atmosphere. Activities involved in different stages of natural gas hydraulic fracturing ('fracking') emit significant amount of NOx and VOCs.



Formation and transportation of ozone is a complex phenomenon that depends on both meteorological factors (such as solar radiation, air temperature, wind speed, and humidity) and anthropogenic emissions. The number of gas wells on Barnett Shale has been exponentially increased in the recent decade. That means, precursors of ozone (NOx and VOCs) have been increased in Dallas-Fort Worth area. In order to understand the impact of fracking activities on local ozone pollution we need to remove the effect of meteorological parameters first and then compare pollution of near-fracking sites with those farther from fracking activities.

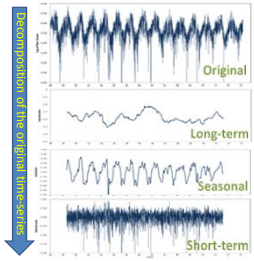


Objectives

The hypothesis of this research is that the long-term characteristics of ozone pollution has been changed due to the fracking activities in DFW area. Since the fracking activities are not evenly distributed in DFW area, the objective of this research is to show the difference between meteorologically independent ozone pollution trends in fracking counties versus non-fracking counties.

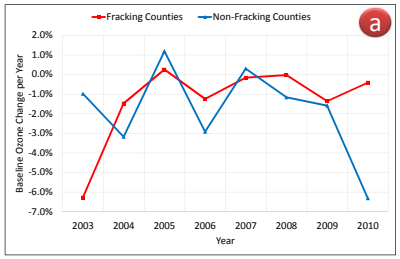
Method

Raw ozone time-series contain pollution information with different time scales, and therefore it should be decomposed to be useful in analysis. Kalmogorove-Zurbenko filtering method [2] is applied to decompose the recorded ozone and meteorological parameter time-series to long-term, seasonal term, and short-term ozone. Then a linear regression between surface temperature, solar radiation, and ozone is calculated. The residuals of calculated ozone and original ozone time-series is taken as "meteorologically independent" (MI) ozone. The process has been repeated for the recorded data in sixteen state air monitoring sites in the DFW area from 1997 to 2014. The long-term trend and spatial relationship of MI ozone time-series have been calculated. Then a comparison is made between monitoring sites close to the fracking activities and those farther away from gas wells.

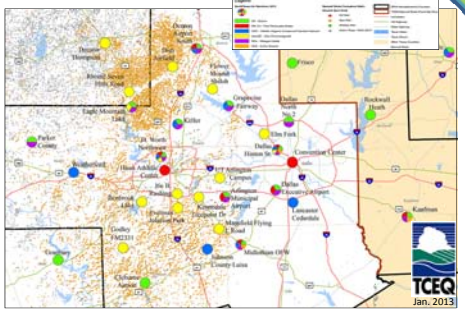


Results

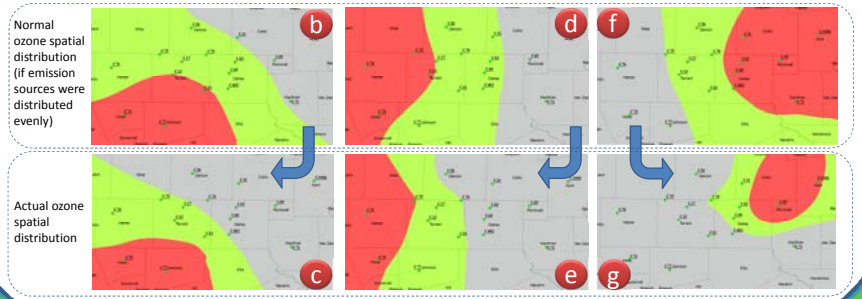
Change in MI ozone baseline (long-term + seasonal)



North Texas Gas and Oil Wells [3]



Impact of spatial distribution of uneven gas well activities on the spatial extent of local ozone problem



Discussion

Analysis of meteorologically independent (MI) ozone time-series can explain the overall change in ozone only due to emission sources. Plot (a) shows the annual change in the baseline of MI ozone in two sets of monitoring sites in DFW area (negative and positive values on the Y axis means, respectively, decrease and increase in ozone). Because of the better performance of emission sources and stronger air regulations in the recent years the annual change is almost always negative. That is, ozone baseline in DFW area is generally decreasing. However those sites located farther from fracking activities (such as Kaufman, Rockwell, Dallas, Frisco, and Greenville) show faster drop. On the other hand, the average annual change in the sites closer to fracking activities (such as Ft. Worth, Parker, Granbury, Keller, Denton, and Cleburne) is getting closer to positive values (i.e. ozone is increasing). As a conclusion, plot (a) shows how much non-fracking counties are better in decreasing the baseline of ozone.

Fracking activities are concentrated on the left side of DFW area. When the distribution of emission sources in an area is even then the spatial distribution of ozone problem should be even. That means, the correlation coefficient between short-term MI ozone time-series of two monitoring sites is linearly related to their distance. Therefore, when we plot the values of correlation coefficients on the geographical map of the area, we expect a plot with linear spatial distribution of correlation (such as plots (b), (d), and (g)). However when the emission sources are not evenly distributed, there is a spatial bias and therefore the linear distribution would be 'skewed' in one direction. Plot (b) and (d), show normal linear distribution of correlation values, respectively, for C73 and C76 monitoring sites. But because these two sites are surrounded by fracking activities, they have weaker correlation with those site located out of the fracking activities. Therefore plots are skewed away from non-fracking counties (plot (c) and (e)). With same logic, the actual plot for C69 (plot (g)), is skewed away from gas wells, because C69 is in the non-fracking county and therefore has weaker correlation with fracking county sites. As a conclusion, the uneven distribution of gas wells, as ozone precursor sources, has created spatial bias in ozone distribution. That is, because of fracking activities, ozone is a local problem more than it normally should be. Fracking county sites have stronger correlation because they are surrounded by same sources of ozone precursors.

Conclusion

For the first time, this research show the negative impacts of fracking activities on the ozone pollution in DFW area. Sites closer to gas wells show worse long-term trends and also stronger spatial correlation. That is, fracking activities have disproportionally localized ozone problem. Further researches, including detailed and comprehensive air quality modeling are required to make better understanding of source participation in air pollution. The results would be very helpful for regulatory purposes.

References

[1] http://www.rrc.state.tx.us/barnettshale/barnettshalewellcount_1993-2013.pdf
[2] Rao, S. T., et al. "Space and time scales in ambient ozone data." *Bulletin of the American Meteorological Society* 78.10 (1997): 2153-2166.
[3] http://www.tceq.state.tx.us/assets/public/implementation/barnett_shale/bs_images/bsMonitors.png