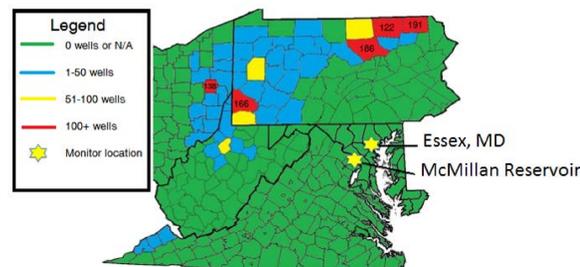


# Regional Air Quality Impacts of Hydraulic Fracturing and Natural Gas Activity: Evidence from Ambient VOC Observations

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## Natural Gas and Hydraulic Fracturing

States surrounding Maryland have begun the processes of horizontal drilling and hydraulic fracturing to obtain significant amounts of natural gas from within the Marcellus shale. The composition of this natural gas was found to be 79-96% methane, with 3-16% ethane<sup>1</sup>, and natural gas operations have been estimated to lose anywhere from 0.42-17.3% of recovered gas to the environment<sup>2-8</sup>.

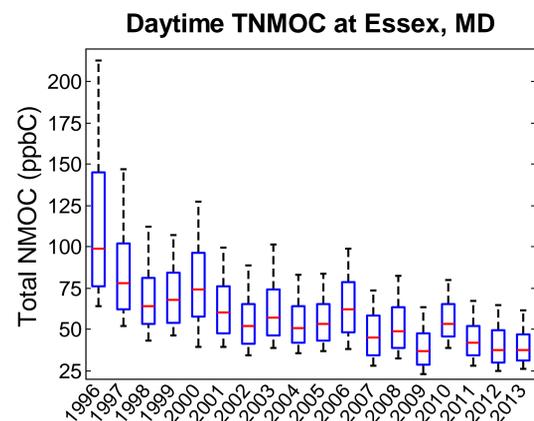


Number of new unconventional natural gas wells drilled by county in 2013. The northern and southwest counties of Pennsylvania contain the most wells.

## Ambient VOC Measurements

An EPA PAMS site at Essex, MD has recorded hourly values for ethane and other VOCs from June through August for over a decade, providing a rich data set for analysis. Daytime (10am-7pm) concentrations were considered because of boundary layer stability.

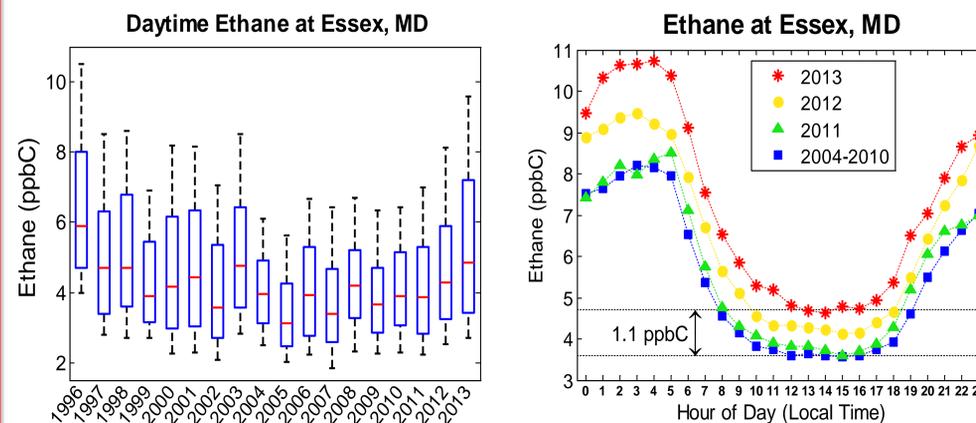
The amount of total nonmethane organic compounds at Essex has continued to decrease over the years.



Daytime concentrations are shown by box and whisker plots above. The box provides the 25<sup>th</sup> and 75<sup>th</sup> percentiles, with the median represented by the red bar, and the whiskers extend to the 10<sup>th</sup> and 90<sup>th</sup> percentiles.

## Essex, MD Ethane Concentrations

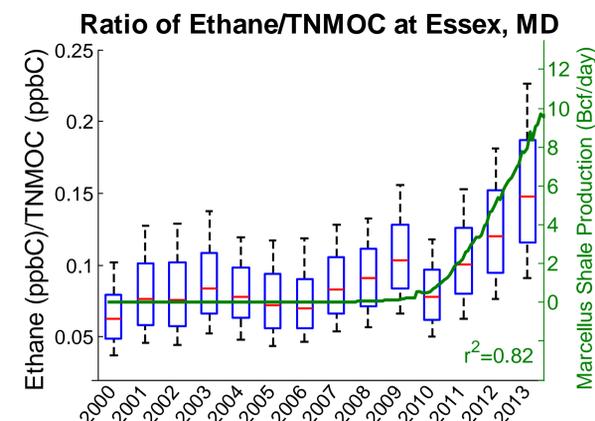
Despite an initial decline, ethane concentrations have increased in the most recent years. Between 2004 to 2010 concentrations were relatively constant, but began to increase starting in 2011.



The recent increase in ethane concentrations is observed in both the box and whisker time series (left) and the diurnal cycle (right).

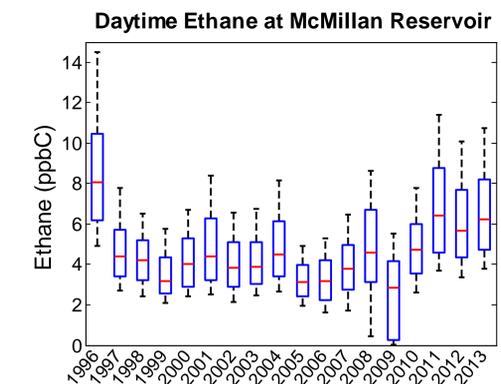
Statistical analysis using the Kruskal-Wallis and Steel-Dwass post-hoc tests found significantly greater concentrations in 2012 and 2013. Ethane concentrations in 2013 were also found to be significantly greater than in 2012.

Using ethane as a tracer for natural gas emission sources, it can be seen below that natural gas has been increasing as a percentage of the total VOC emissions and is well correlated with EIA-reported Marcellus Shale production rates.

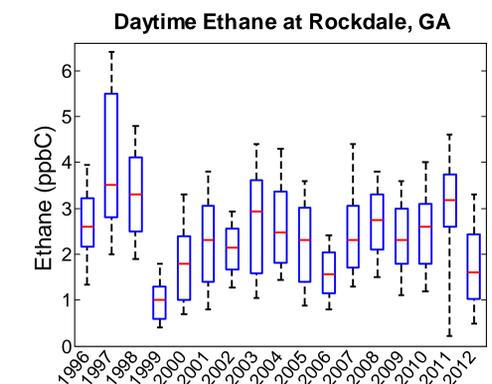


## Other PAMS Sites

Another PAMS site in nearby Washington, DC also displayed significantly greater ethane concentrations in recent years.



Atlanta, GA has no new regional natural gas operations and can serve as a control environment. Ethane concentrations show no recent upward trend, as 2012 was significantly low.



## Conclusions

Over the past couple years, ethane concentrations have grown significantly at Essex, MD. Other natural gas sources such as landfills and CNG usage do not appear to be capable of causing this increase. This trend suggests that natural gas operations can impact not only locations in close proximity but areas great distances downwind as well.

## References

- <sup>1</sup>Bullin and Krouskop, *Oil & Gas Journal*, 107(10), 50-57, 2009.
- <sup>2</sup>Allen et al., *PNAS*, 110 (44): 17601-17602, 2013.
- <sup>3</sup>Caulton et al., *PNAS*, 111(17), 6237-6242, 2014.
- <sup>4</sup>Howarth et al., *Climatic Change*, 106(4), 679-690, 2011.
- <sup>5</sup>Karion et al., *Geophys Res Lett*, 40(16): 4393-4397, 2013.
- <sup>6</sup>Kirchgessner et al., *Chemosphere*, 35(6), 1365-1390, 1997.
- <sup>7</sup>Peischl et al., *J Geophys Res-Atmos*, 118(10), 4974-4990, 2013.
- <sup>8</sup>Petron et al., *J Geophys Res-Atmos*, 117(D4), 2012.