Detection and Quantification of Methane Seeps in Northern Pennsylvania

Brandon Clark[1], Thomas Lauvaux[1], Kenneth Davis[1], Kathryn Wheeler[2], Zach Barkley[1]
1. The Pennsylvania State University 2. University of Delaware

Abstract

Due to the increase of drilling in the Appalachian basin, the level of concern of methane seepage has risen. There has been an ongoing debate whether fracking of the Marcellus shale has caused methane emissions to the atmosphere or if the seeps are occurring naturally. Geochemical studies have been conducted on the northern Appalachian basin of Pennsylvania and they have detected dissolved methane present in the aquifers overlying the Marcellus shale formation. Both the Catskill and Lock Haven Formations are above the Marcellus shale, a middle Devonian shale. The Catskill and Lock Haven aquifers account for a large part of the drinking water supply in Pennsylvania. Methane in the atmosphere near the surface was detected and analyzed using a Picarro G2302 Analyzer. The analyzer makes measurements of Carbon dioxide, Carbon monoxide, Methane and water vapor with a sensitivity of parts per billion (ppb). Measurements were taken approximately 2 meters above the surface of the Earth. Enhanced atmospheric methane mole fractions in areas of potential natural seeps were identified.

Introduction

Emissions of methane into the atmosphere may have increased due to the accelerated pace of drilling in the Marcellus shale. This middle Devonian organic rich black shale is present throughout the Allegheny plateau of the Appalachian Basins. Recent studies have been conducted on this topic using Mud gas logging (MGL) and water samples. Baldassare et al., (2013) discovered three different mixtures of methane isotopes present in the Catskill and Lock Haven formations. They concluded the methane gas found in the mud and water to be from sources other than the Marcellus shale due to having a different isotopic composition.

Objectives

- Identify geologic areas of Pennsylvania where natural methane seeps may exist.
- Measure methane content of the atmosphere in the desired regions.
- Evaluate whether or not the atmospheric methane data suggests the presence of measurable, natural methane seeps.

Methods

Once the target areas were defined, atmospheric methane data collection was conducted using the Picarro instrumentation (Figure 1). The instrument was set up in a vehicle as we drove around collecting atmospheric data. The data was then synchronized with the GPS utilizing Interactive Data Language (IDL). A Google Earth plot was generated using IDL, illustrating the methane measurements in parts per million . With the Google Earth plot we are able to indicate the areas of local atmospheric mole fraction enhancements with specific latitude and longitude. The plots were overlaid against our database, which included farm, landfills, compressor stations, and well data (Figure 2).

Figure.1 Picarro G2302 Analyzer.

Preliminary Results

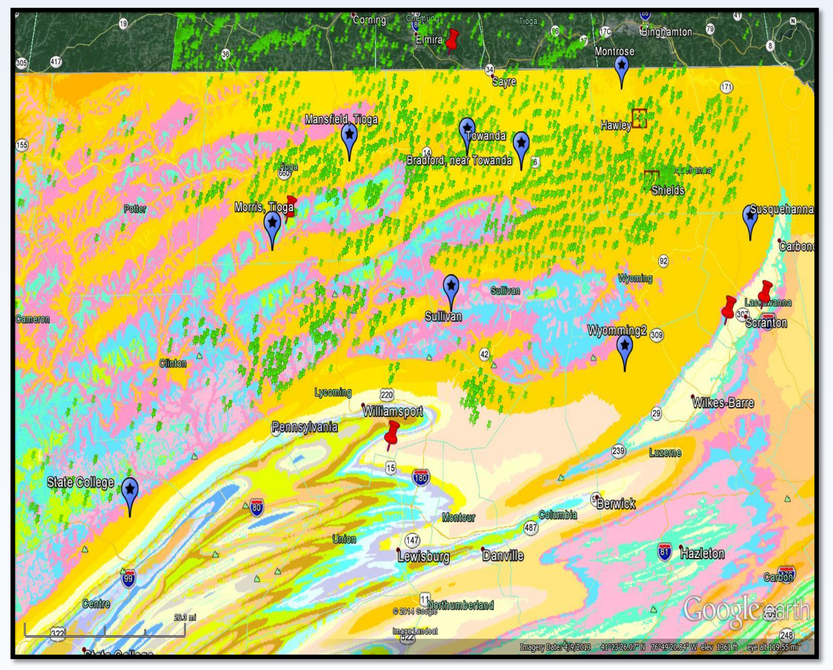

Figure. 2 Map of Pennsylvania's geologic formations (PA DCNR 2009). Green pins are wells, red pins are landfills and blue pins are potential locations of natural seeps.

- After all the collection of well and farm data a few areas of interest were chosen (blue pins). Ideal areas for potential natural seeps were at least a mile away from either farms, landfills, well pads, or compressor stations.
- Target areas were desired to be near wetlands, rivers, or lakes and in the Catskill or Lock Haven formations, which are in the yellow and orange region of the map in fig. 2.

Results

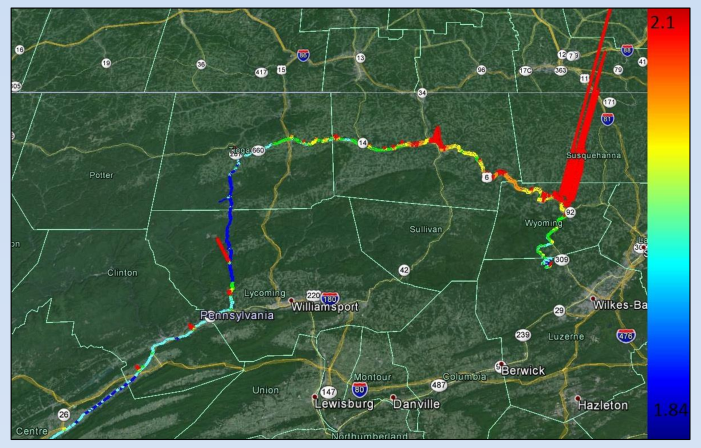

Figure. 3
Google Earth Plot of a drive around conducted on July 18th from 5 am to 2pm, driving from east to west. The instrument recorded methane measurements ranging from 1.84 parts per million(ppm) to 2.1 ppm and higher. The maximum value is 17.1 ppm recorded near a compressor station. The median value was 1.941 ppm and the mean was 2.179 ppm. Although there were a significant amount of readings above 2.1 ppm, we used 2.1 as a maximum color scale limit in order to see smaller peaks within the dataset. Mole fraction is also proportional to height of the bars.

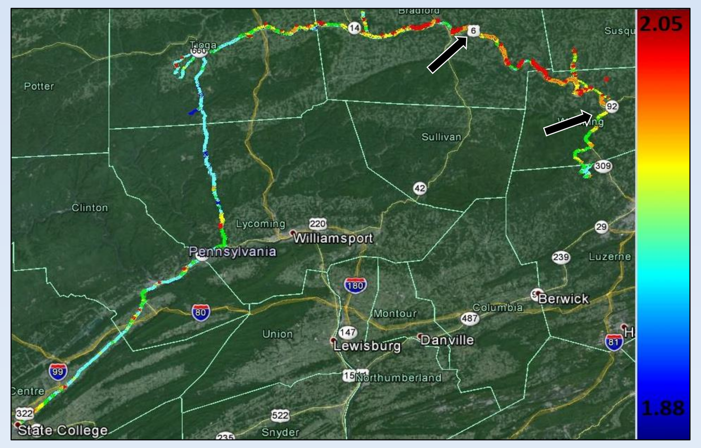

Figure. 4
Google earth plot of the same day as figure 3., but it has a maximum of 2.05 ppm in order to illustrate small changes of 0.01 ppm. We traveled along the Susquehanna River between the two black arrows in which we noticed an enhancement of about 50 parts per billion on average. This enhancement spans over 30 miles making it significant

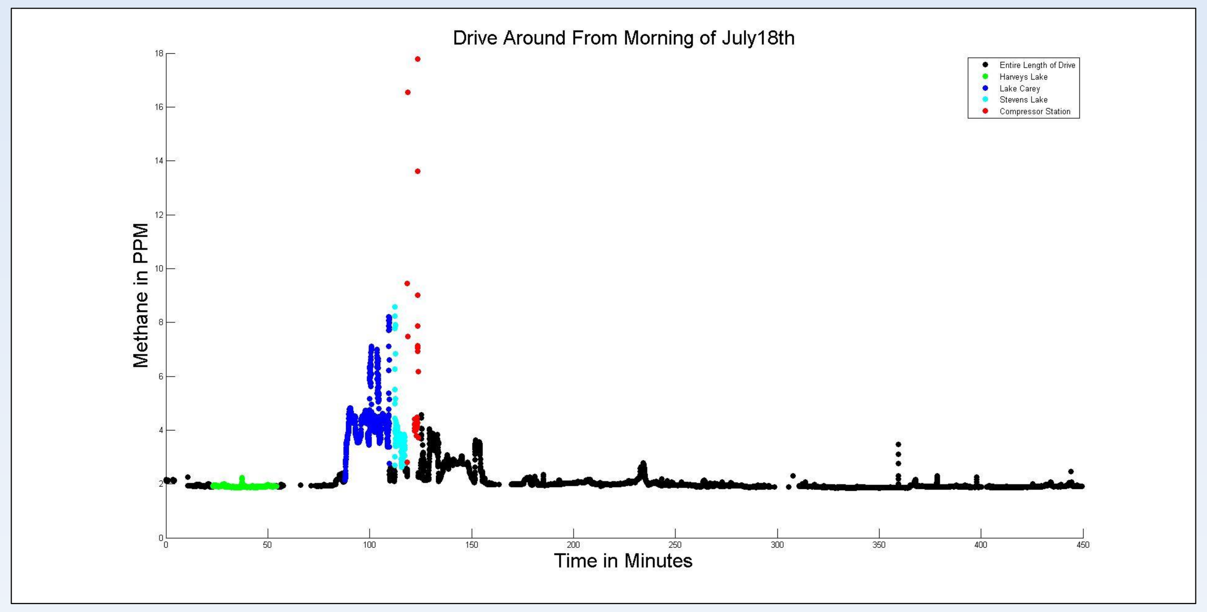

Figure. 5
This graph is a time series plot of the drive around from July 18th, illustrating the different areas we conducted measurements at. We recorded significant readings at Lake Carey and Steven's Lake, maxing out around 8ppm and 6ppm respectively. However, when we went to Lake Harvey we did not record any significant measurements.

Discussion & Future Work

Detection of methane seeps using atmospheric data was conducted successfully. We were able to detect areas of local enhancement near wetlands, and compressor stations. After reading other publications, we hypothesized that seeps may be occurring naturally at wetlands. We were able to detect significant constant enhancement of 4ppm above background at Lake Carey and approximately 2-3ppm above background at Steven's Lake. However when we drove to Lake Harvey our readings there were lower than the local background. These measurements were taken between 5 and 8 am before the atmospheric boundary layer begins to mix. We also noticed from all four of our methane survey drive arounds that when we travel along the Susquehanna River, we notice an enhanced background of approximately 50 ppb along the entire drive along the river. We are not labelling these areas as natural seeps just yet, but they potentially could be. We plan to continue on making measurements in the future with the Picarro and use a new instrument that will be able to measure carbon 13 isotopes. With those isotope measurements we hope to quantify if the methane we are detecting is thermogenic or microbial composition. Additional future work would attempt to quantify the emission rates from these seeps.

References

- Baldassare, Fred, and Mark A. McCaffrey, John A. Harper, 2013. A Geochemical Context for Stray Gas Investigations in the Northern Appalachian Basin: Implications of Analyses of natural gases from Neogene through Devonian age Strata.
- Klusman, R.W., M. Emmelyn Jakel, 2012, Natural microseepage of methane to the atmosphere from the Denver-Julesburg basin, Colorado, Journal of Geophysical Research: Atmospheres, Volume 103, Issue D21, pages 28041–28045.
- Molofsky, Lisa J. and John A. Connor, Shahla K. Farhat, Albert s. Wylie Jr., Tom Wagner, 2011. Methane in Pennsylvania water wells unrelated to Marcellus Shale fracturing, Oil & Gas Journal, December 5th, 2011, pages 54-67.
- Geology map of figure 2. from <http://www.gis.dcnr.state.pa.us/geology/index.html,(2009)>

Acknowledgements

This work was supported by the National Science Foundation through the Network for Sustainable Climate Risk Management (SCRiM) under NSF cooperative agreement GEO-1240507, and by the U.S. Department of Energy's National Energy Technology Laboratory. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or the Department of Energy.