Impacts of Oil and Gas Production on Methane and Ozone Variability in the Denver-Julesburg Basin

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Introduction

The Denver-Julesburg (DJ) Basin is located in northeastern Colorado and extends into southeastern Wyoming and western Nebraska. This study focuses on the area north of Denver which is rich in oil and natural gas resources. The oil and gas industry is the largest industrial source of methane, which accounts for about 10% of US greenhouse gas emissions ("Overview"). In shale-gas production, it has been found that 3.6% to 7.9% of methane from natural gas escapes to the atmosphere over the lifetime of a well via venting and leaks (Howarth et al. 2011 p.7). Methane has global warming potential (GWP) of 28-36 over a 100 year time horizon, but has a lifetime in the atmosphere of only 12 years (EPA.gov). Even though methane lasts for a shorter period of time than carbon dioxide in the atmosphere, it’s pound-for-pound comparative impact on climate change is 25 times that of carbon dioxide.

Ozone is a molecule that protects us from the sun’s ultraviolet radiation when it occurs in the stratosphere, but can be harmful to life in the troposphere. High levels of ozone have been shown to damage crops and cause respiratory problems in humans. Ozone-forming pollutants include nitrogen oxides (NOx), volatile organic compounds (VOCs), and Carbon monoxide (CO). NOx, VOCs, and CO are emitted through combustion by human related activities including industry and vehicles (EPA p. 1-2). Even though most of the pollutants that form ozone are emitted in urban areas, ozone tends to spread out into even concentrations throughout regions surrounding cities, as far as 48 to 80 km from the source of the pollution (EPA, p. 1-2) (Sarkar et al, p. 3). Because ozone concentration is related to human activity one would intuitively expect it to be higher nearer sources of emissions, including oil and gas wells and facilities. This may or may not be true for the DJ Basin.

Objectives

- Find correlations between observed methane/ozone and amount of oil/gas produced near a pod.
- Explore factors that impact methane and ozone variability in the Front Range.
- Generate information that can inform future research.
- Make maps that represent the spatial variability of methane and ozone. Showing the locations and air quality data on a map is a great educational tool that can help policymakers and the general public to better understand how air quality affects citizens. It can also provide clues as to how much of a role oil and gas production is playing in global climate change.

Methods

- Data used for this study was sampled by CU graduate student Ashley Collier during the 2014 FRAPPE (Front Range Air Pollution and Photochemistry Experiment) campaigns in Colorado.
- Data was collected using low-cost (< $1000 each) air quality sensing devices known as U-pods, which I will henceforth refer to simply as "pods". These pods were developed and constructed at CU Boulder. Right Top: Inside of a pod. Pods were set up at various sites, mostly rural, and at varying distances from oil and gas wells and facilities. Right Bottom: Pods being set up at the Boulder Atmospheric Observatory for co-location calibration. Calculations, statistical analysis, and plotting were performed using MATLAB. I wrote a loop function to calculate cumulative production within radius of each pod location. Then I plotted data and used the curve fitting tool to find correlations between methane/ozone readings and oil/gas production.
- Maps were created in ArcGIS ArcMap 10.2, using data from COGSC and the US Census Bureau.

Ozone variability was not found to be correlated to oil production within the DJ Basin (Figures 3 and 4). Although any correlation found is inverse, this is most likely due to chance and outside conditions. Despite the fact that ozone is formed from pollutants emitted by oil and gas related activities, it does not vary on a small enough scale for us to make conclusions as to the causes of ozone variability in the DJ Basin. Automobiles and nearby cities are likely causes of the observed variability.

Results and Discussion: Methane

Methane variability was found to be correlated with oil production in the DJ Basin. However, the methane variability plots and regressions were affected by one outlier. The Platteville location had a much higher local production volume for oil and gas than all other pods, yet it read a lower median methane than many of the pods.

With Platteville included, July methane readings vs. oil production have an R-square value of only 0.04641. When the Platteville location is removed (See figures 7 and 8) R-square = 0.759, which implies a strong correlation.

The Platteville readings could have been influenced by other factors such as wind direction. If the wind in that location generally comes from an area with few wells such as the East side, it could explain why methane is lower. It is also possible that other pod locations with higher methane readings are affected by nearby sources of methane including cattle, automobiles, and residences.

Results and Discussion: Ozone

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