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Natural Gas Compressor Station Air Emissions Impact Analysis

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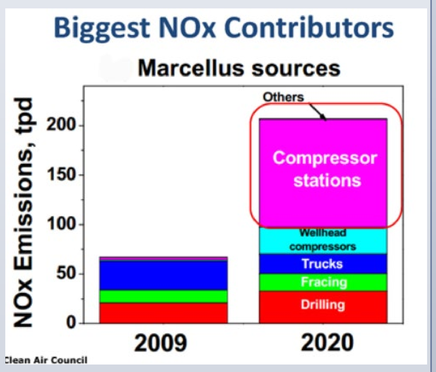
INTRODUCTION

The rise of the Marcellus Shale play, and natural gas fracking methods have led to the installation of over 200 compressor stations in Pennsylvania. These compressor stations help maintain the flow of natural gas so it can move from the well-pad to the market via pipelines. While doing so, they emit air pollutants such as NO2, SO2, and PM2.5, in concentrations that could affect the health of residents outside the setback perimeter of 500 ft.

At 2 select compressor stations in the Marcellus Shale, meteorological data and Gaussian Plume modelling/plotting were used to quantify the impact of such pollutant exposure, in terms of people exposed, and additional economic costs, usually in terms of increased health care coverage.



OBJECTIVES & GOALS

- Answer the overarching question: how does the air dispersion of NOx impact the residents' health/safety in the area surrounding the compressor station setback perimeter?
- Account for the condition where the variance in precipitation rate affects the absorption of air pollutants from a point source.
- Create a better classification system for stability categories, ranging A-F (1-6), where the shift in seasonal day/nighttime hours would be accounted for, as well as the in-between categories ('A-B,' 'B-C,' 'C-D') were adjusted using their GHI (radiation) and wind speed values to fit into only 1 of 6 stability categories.
- In the near future, we plan to quantify the number of residents that would have been exposed to air pollutant levels above the EPA regulatory daily and annual limits, as well as estimate the economic costs/benefits, in terms of health care coverage, that the compressor stations currently may cause, compared to 10%, 25%, 50%, and 100% increases/decreases in setback distance.

METHODS

- The application MATLAB R2021a was utilized for Gaussian Plume modelling, plotting, and advection + deposition factors.
  - Coding for concentration matrices were used to repeatedly execute the same calculations for all desired differences in variables like crosswind & downwind distances, atmospheric stability, etc.
- Meteorological and calculated (stability) data from Excel, imported into MATLAB for implementation.

$$c = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right)\right]$$

Table 3. Guidelines for determining Pasquill-Gifford stability classes

Surface wind speed (ms^{-1})	Day with insolation: Strong	Moderate	Slight	Night: Overcast or ≥ 4/8 low cloud	≤ 3/8 cloud
2	A	A–B	B	–	–
2-3	A–B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C–D	D	D	D
6	C	D	D	D	D

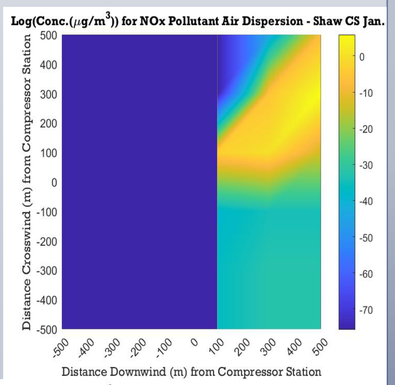
- Body proportions and average height data from online sources were used to estimate the average height of the nostril entrance of a person in the United States for the breathing-level plane for air pollutants.
  - This determined the z (height) plane at which the pollutant concentrations would be modelled at.
  - Average height of 5'6.5", and body proportions such as from the chin to the hairline is 1/9 of a person's height, and from the chin to the nostrils is 1/3 of the face's length.

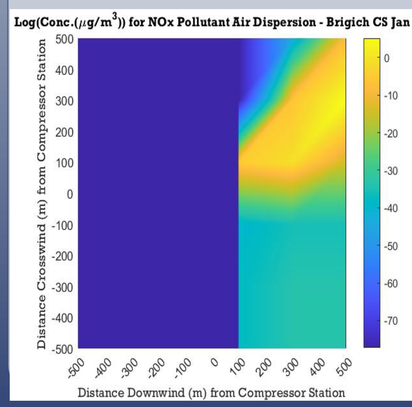
LIMITATIONS

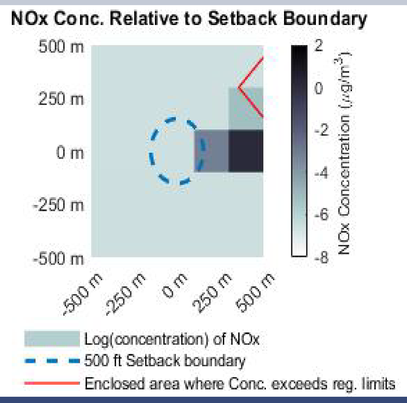
- Occasional hours of undocumented meteorological data.
  - Since Gaussian Plume is a steady-state model, we assumed the missing data points to be the same as the hour before, or the same as the closest hour if multiple hours in a row were missing.
- Stack height data had no exact measurements, therefore, pictures were used to estimate that height in meters.
- Meteorological data from the closest airports will vary slightly compared to the actual weather at compressors.
- Low computing power led to sample size data and low resolution for plotting
- Weaknesses of using a Steady-State Gaussian Plume Model include:
  - Air dispersion alterations due to terrain
  - Wind gusts are not truly accounted for

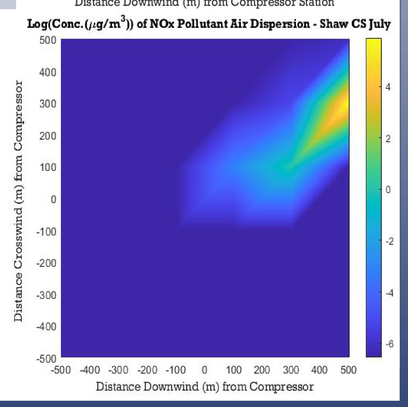
RESULTS

- For NOx concentrations at a breathing plane of 1.56398 meters:
  - At Shaw CS, in both January and July, the max. concentration (at 500m downwind and 300m crosswind) reached over 360 micrograms per cubic meter, and did not fluctuate very greatly by hour.
  - At Brigich CS, in both January and July, the max. concentration surpassed 160 micrograms per cubic meter at the same cross and downwind distances, with little variance.









FINDINGS & SUGGESTIONS

- This very small-scale sample size results will show just an indication of what the large-scale conclusions may be:
  - It is extremely likely that there are people outside the setback distance that are exposed to NOx concentrations above the EPA's daily and annual regulatory limits of 104.13 ug & 196.471 ug respectively.
  - Wind patterns and compressor station emission rates appear to play large roles in pollutant dispersion, while stability seems to have a much slighter impact.
- Allocating space and resources to plant vegetation, especially deciduous trees, in the area, is one way to reduce the risk of nearby residents' exposure to PM2.5.
  - "The total amount of PM2.5 removed annually by trees varied from 4.7 tons in Syracuse to 64.5 tons in Atlanta, with annual values varying from $1.1 million in Syracuse to $60.1 million in New York City. Most of these values were from the effects of reducing human mortality," (Nowak).

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