Application of AERMOD in Air Dispersion Modeling of Methane Emissions: A Case Study from Karnes County in the Eagle Ford Shale

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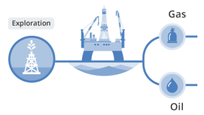
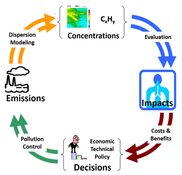
Motivations

Unconventional oil and gas development (UOGD) is rapidly expanding in the U.S., increasing the urgency for assessing community exposure to pollutants and health impacts.



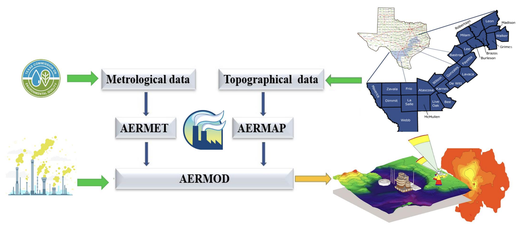
The Eagle Ford Shale (EFS) is a major oil and gas production region with diverse emission sources, requiring identification of the primary contributors to air pollution.

Objectives



This study quantifies the influence of UOGD emissions on air quality and exposure in Karnes County, TX, evaluates the relative roles of emissions and meteorology, and assesses the sensitivity of these results to spatial and temporal scales erelevant to exposure and health studies.

Methodology



Meteorological and topographical data are processed using AERMET and AERMAP to prepare for AERMOD input

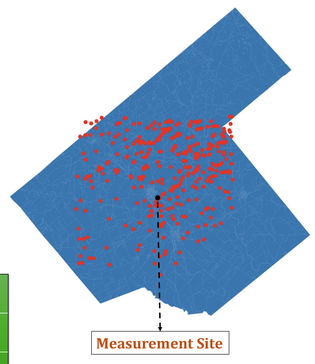
Emission data, including rates and locations, are provided by the Center for Energy and Environmental Resources

AERMOD is applied to conduct air dispersion modeling across multiple time scales, as represented in the results.

Study Area

- The Eagle Ford Shale (EFS) region has **17,414** production sites.
- Karnes County, TX leading in oil, gas, and condensate production.
- A study focused on **402** well process locations, identifying **1,029** emission sources, including tank batteries, pneumatic control valves, and leaks.

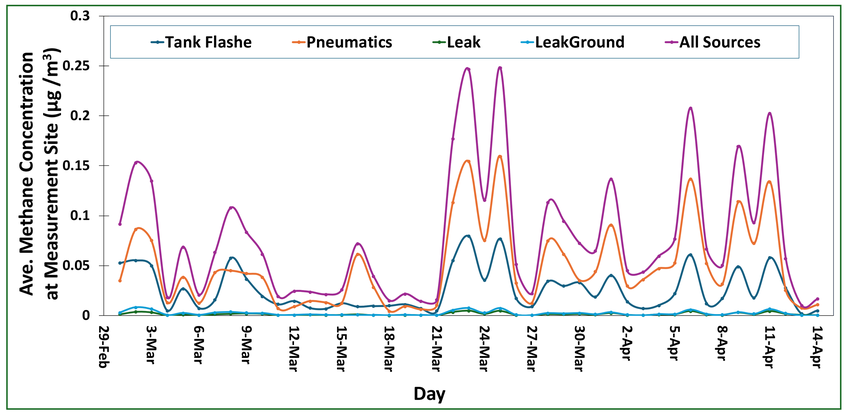
Source Category			
Tank Battery	Pneumatics	Leak	Leak Ground
325	316	197	191



Temporal Results

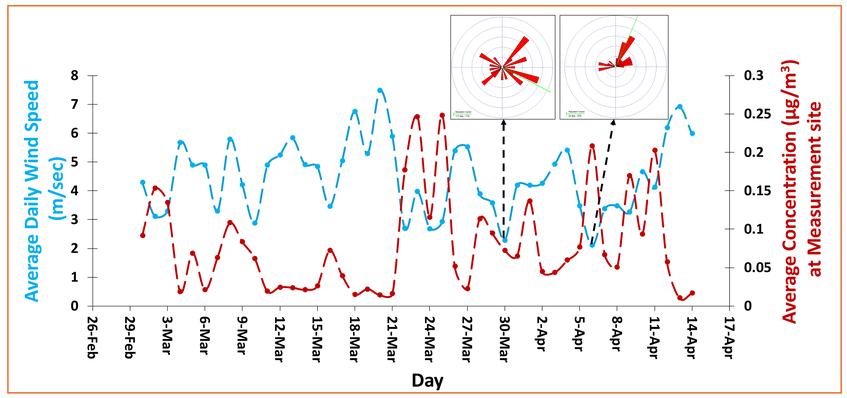
A: Time Series Analysis for Emission Source Categories

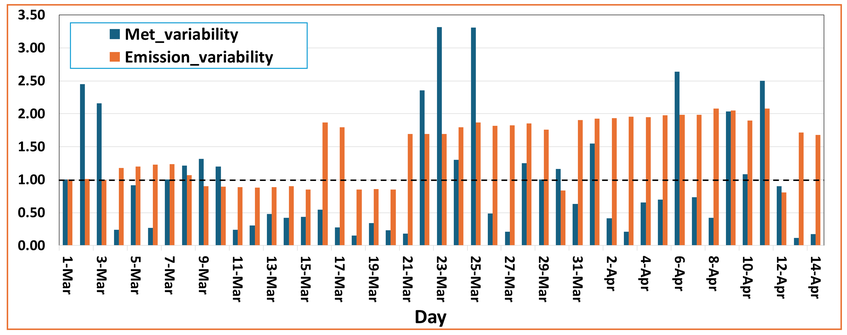
- The time series analysis indicates that pneumatic valve sources have the greatest impact on the average methane concentration

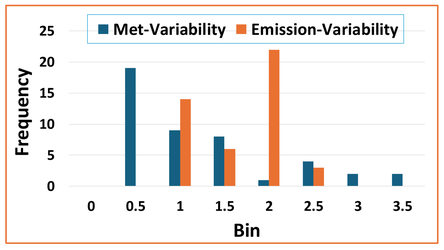


B: Assessing the Effects of Meteorological and Emission Variabilities

- Meteorological analyses demonstrate the impact of prevailing wind direction and speed on the average methane concentration.
- Variability analyses indicate that changes in meteorological conditions have a greater impact on average concentration levels than variations in emissions.



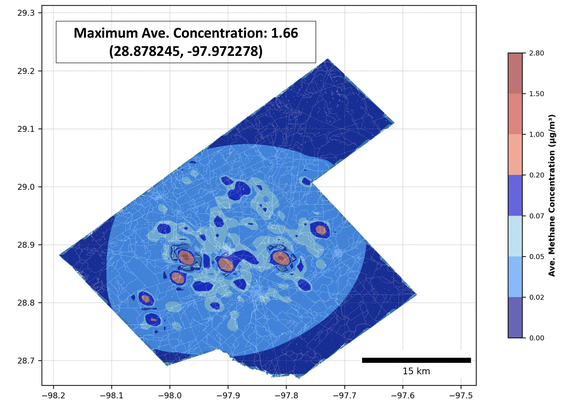




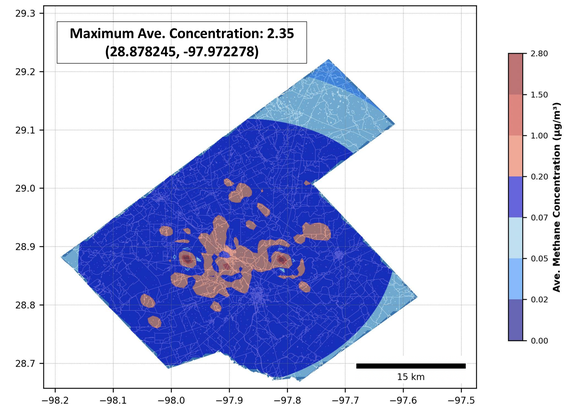
Met-Variability		Emission-Variability	
Bin	Frequency	Bin	Frequency
0	0	0	0
0.5	19	0.5	0
1	9	1	14
1.5	8	1.5	6
2	1	2	22
2.5	4	2.5	3
3	2	3	0
3.5	2	3.5	0
Standard Deviation			
0.866		0.473	

Spatial Results

A: Daily Concentration Contour Map for Methane Over Karnes County



B: Monthly Concentration Contour Map for Methane Over Karnes County



Conclusion

- The maximum daily average in Karnes City is 0.25 µg/m³ at the measurement site.
- Pneumatic control valves contributing 64% during the period study.
- Based on the meteorological and emission variability analyses, changes in meteorological conditions have a greater impact on the average concentration than emission changes.
- High-concentration zones are primarily located in the central part of Karnes County, where most emission sources are concentrated.

Future Works

- Increasing the number of sources to approximately 7,500, including emission sources at various locations situated at different distances from the measurement site.
- Extending the study period.
- Considering other source categories, such as flares.
- Evaluation of Model Performance through Comparison with Observational Data
- Spatial exposure modeling throughout Karnes County.
- All steps will be applied to other pollutants, such as ethane, propane, and hexane.

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