Near-Source Safety and Health Risks of Oil and Gas Super Emitters

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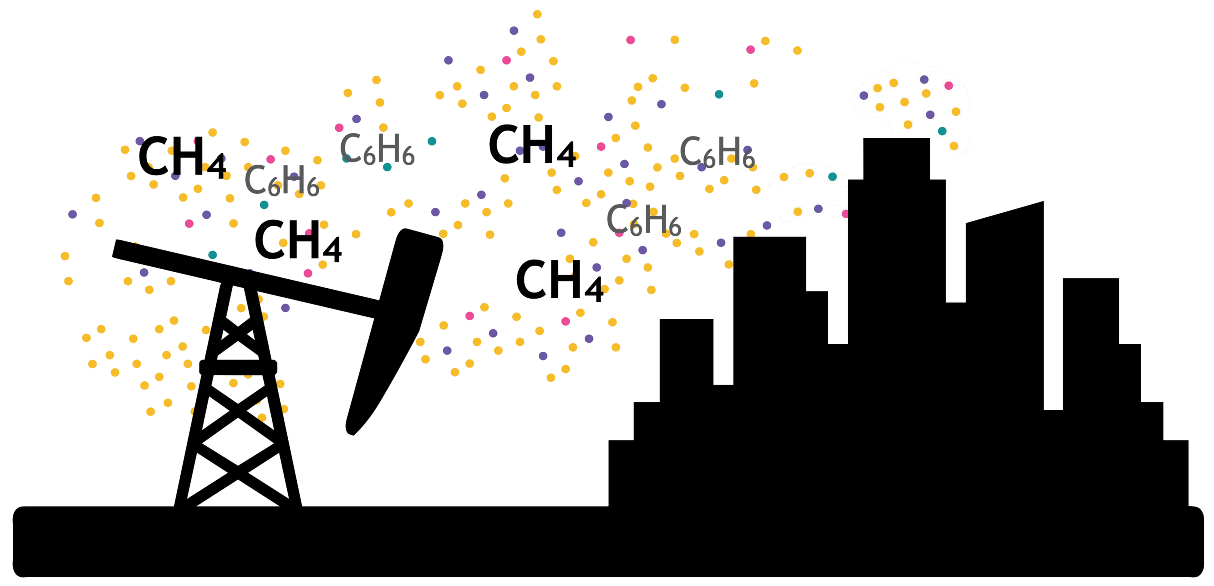
Chowdhury G. Moniruzzaman*, Sadia Afrin*, Sofia Bisogno*, Jeremy K. Domen*, Christos Efstathiou*, Lee Ann L. Hill*, Jessie M. Jaeger*, Jasmine Lee*, Quintin Munoz*, Sebastian T. Rowland*, Daniel Bon+, Daniel H. Cusworth+, Kelsey R. Bilsback*

*PSE Healthy Energy, Oakland, California, United States, +Carbon Mapper, Pasadena, California, United States,

Corresponding Author Contact: chowdhury.monir@psehealthyenergy.org

1 Oil and Gas Loss of Containment Events

Methane leaks are prevalent across the oil and gas supply chain. These leaks have climate impacts, however, less is known about the air quality and health implications of non-methane volatile organic compounds (NMVOCs) that are co-emitted with methane.



2 Air Quality Modeling

Our methodology is outlined in **Figure 1**. We estimated the air quality impacts and potential health and safety risks of oil and gas leaks at sites across the U.S. by combining methane measurement data from aircraft surveys conducted by Carbon Mapper,[1] publicly-available NMVOC gas composition measurements, and dispersion modeling.

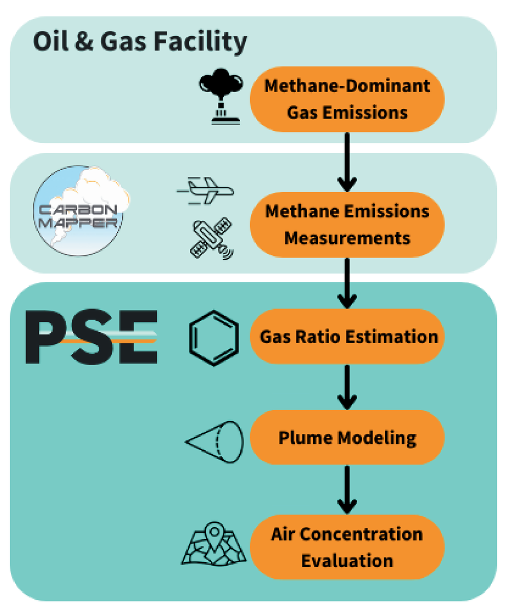


Figure 1. Schematic of our methodology.

- **Air Quality Modeling:** We estimated downwind concentrations of both methane and benzene using AERMOD,[2] a regulatory-grade Gaussian dispersion model. Due to intermittent aircraft flyovers, there is uncertainty in the overall magnitude and duration of the release. We simulated one month and assumed the release was constant across the month. Source parameters were determined using Google Earth satellite imagery and publicly available oil and gas infrastructure information.
- **Gas Composition Ratios:** To convert the methane concentrations to benzene concentrations, we applied state- and infrastructure-category-averaged gas composition ratios, estimated based on composition data obtained from air permits from environmental state agencies or scientific literature.
- **Safety Benchmark:** To assess safety risk, we compared one-hour methane air concentrations to the National Institute of Occupational Safety and Health (NIOSH) Immediately Dangerous to Life or Health (IDLH) value of 0.5%.
- **Health Benchmark:** We compared hourly benzene estimates to the acute Reference Exposure Level of 8 ppb from the California Office of Environmental Health Assessment (OEHHA REL) and the acute Effects Screening Level of 53 ppb from the Texas Commission of Environmental Quality (TCEQ ESL).

3 Loss of Containment Case Studies

We evaluated three methane loss of contaminant events from oil and gas sources (Table 1). The first leaks were from an oil and gas processing facility in the Permian Basin in Stanton, TX.; the second from an oil and gas distribution line at Orange, CA; and the third from a well in the Denver Basin in Thornton, CO.

Table 1. Summary information for each case study.

	Stanton, TX	Orange, CA	Thornton, CO
Measurement Date	October 5, 2019	September 18, 2017	September 22, 2021
Modeled Month	October 2019	September 2016[a]	September 2021
Infrastructure Type	Processing facility	Distribution line	Well
Methane Rate	5,066 kg hr^{-1}	690 kg hr^{-1}	1,179 kg hr^{-1}
Mean Benzene:Methane Mol Ratio (No. Samples)	9.949e-5 (7)[b]	5.965e-06 (44)[c]	7.134e-4 (149)[d]
Max Distance with Safety Exceedance (NIOSH IDLH)	107 meters	25 meters	No exceedance
Max Distance with Health Exceedance for Benzene (OEHHA REL 8 ppb)	2,007 meters	32 meters	6,093 meters
Max Distance with Health Exceedance for Benzene (TCEQ ESL 53 ppb)	524 meters	No exceedance	1,136 meters

[a]Modeled month is different than measurement date due to availability of meteorological data at the air district. [b]Pring et al., *Eastern Research Group*, 2012; [c]Lebel et al., *Environmental Science & Technology*, 2022. [d]Rowland, S. T. et al., *American Geophysical Union Fall Meeting, 2022*

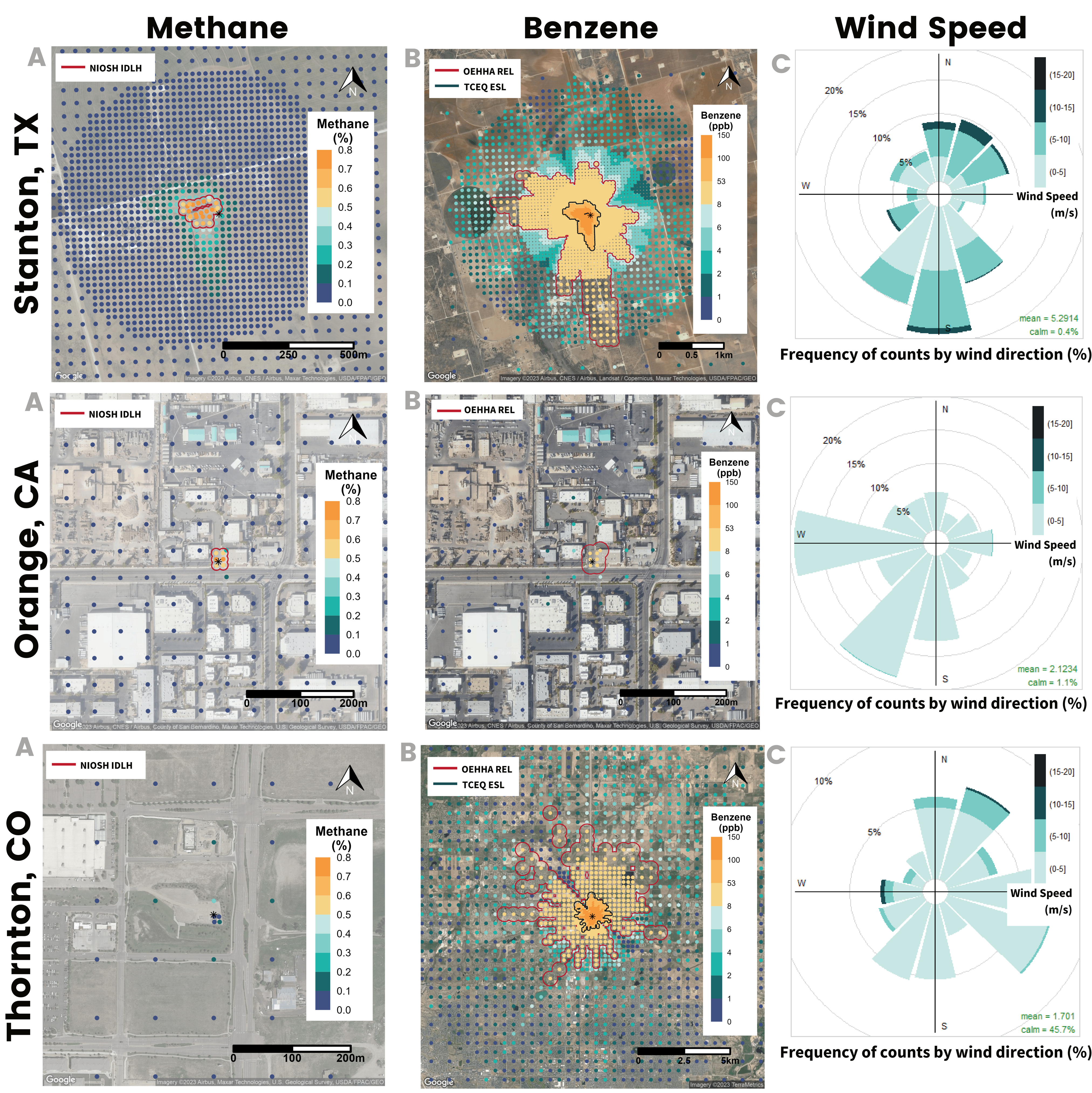


Figure 2. Maximum one-hour average methane (A panels) and benzene (B panels) concentrations at each receptor. The contour line on each plot shows the air concentration benchmark exceedance area and includes receptors that had at least one hour of exceedance. The wind rose for each modeled time period are in the C panels.

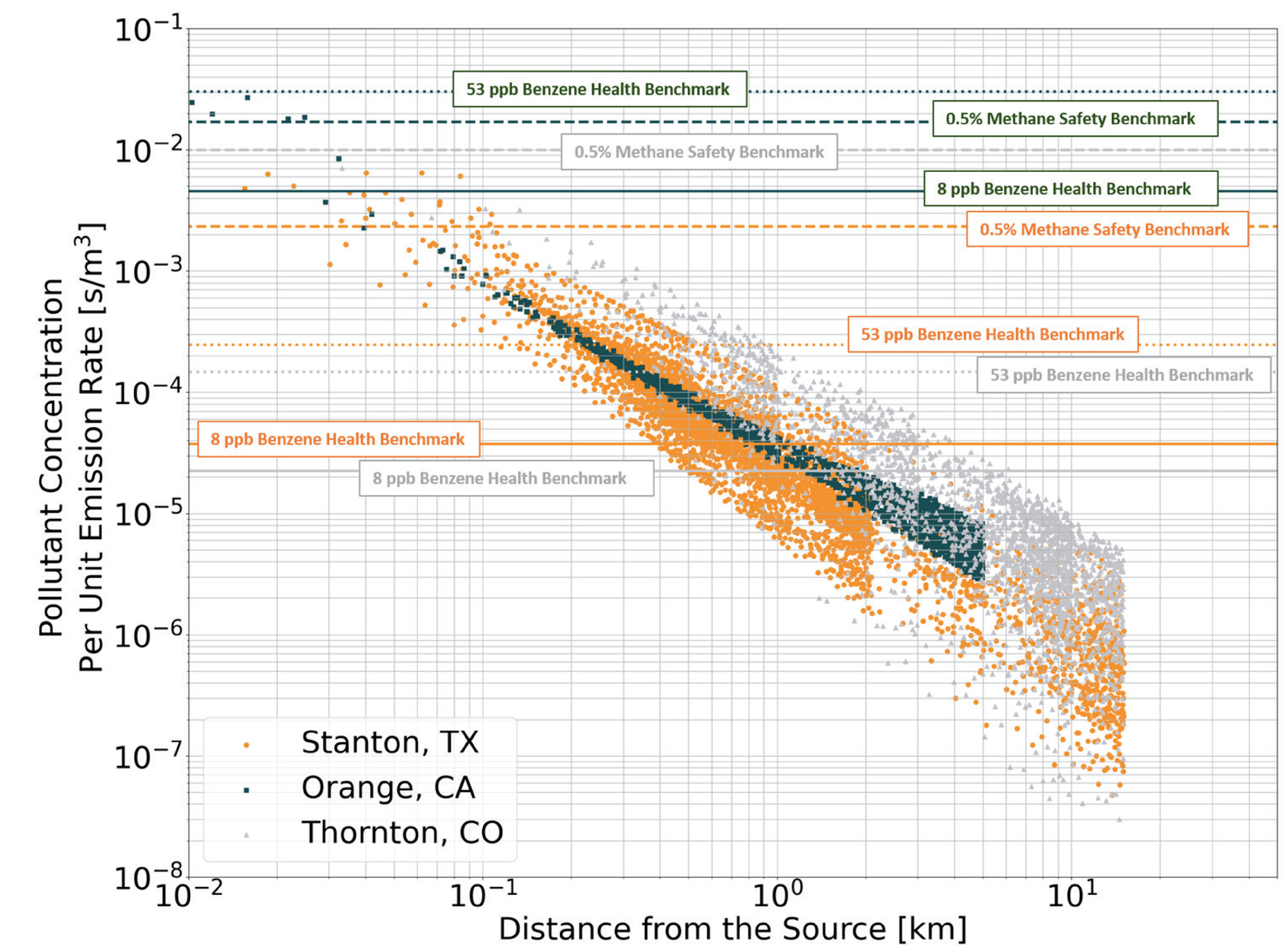


Figure 3. Maximum one-hour average concentration versus distance for three different case studies from oil and gas infrastructure in three different states. The horizontal lines indicate the safety and health benchmarks and the receptors that fall above these lines exceed these benchmarks.

- For the **Stanton, TX case study** (5,066 kg/hr), we found that our estimated methane air concentrations exceeded the safety benchmark (0.5% methane) out to 107 meters. Further, the estimated benzene air concentrations exceeded the OEHHA REL health benchmark (8 ppb benzene) out to 2,007 meters and the TCEQ ESL benchmark (53 ppb benzene) out to 524 meters.
- For the **Orange, CA case study** (690 kg/hr), we found that our estimated methane air concentrations exceeded the safety benchmark out to 25 meters, while the estimated benzene air concentrations exceeded the the OEHHA REL health benchmark out to 32 meters and there was no TCEQ ESL exceedance.
- For the **Thornton, CO case study** (1,179 kg/hr), we found that the estimated methane air concentrations did not exceed the safety benchmark, but the estimated benzene air concentrations exceeded the OEHHA REL health benchmark out to 6,093 meters and the TCEQ benchmark out to 1,136 meters.

4 Summary and Conclusions

- Our study demonstrates the safety, air quality, and public health relevance of methane leaks across the oil and gas sector.
- We found that even leaks that did not pose safety (i.e., explosivity) risk could still be a cause of concern for health risk.
- NMVOC content varied by source, indicating that future health risk assessments should consider both emission magnitude and source-specific NMVOC content to assess health risk.

References:
1. Carbon Mapper. (2023 October). *Data.* https://carbonmapper.org/data/
2. U.S. Environmental Protection Agency. (2022 June). User's Guide for the AMS/EPA Regulatory Model (AERMOD), EPA Report EPA-454/B-22-007.

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