ATMOSPHERE INNOVATION RESEARCH
BOULDER AIR

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October 11, 2024

To:

Town of Erie
645 Holbrook Street
Erie, CO 80516

Attn: Dr. David Frank

Re: Erie Regional Air Quality Study – Highlights

Dear Mr. Frank,

Please find included with this letter the report of selected findings and highlights from the Erie Regional Air Quality Study since its inception in October 2021.

Thank you for providing this opportunity for air quality monitoring to Erie citizens and the Town of Erie. We would be happy to discuss any questions that you, other staff, or Erie citizens may have.

Sincerely,

Detlev Helmig

Detlev Helmig
Boulder AIR LLC

Summary Report

Erie Air Quality Study Important Findings

Prepared by Detlev Helmig, Dani Caputi, Gabriel Greenberg, and Susan Simoncic
Boulder AIR LLC

October 2024

The air monitoring station at the Erie Community Center (ECC)

Abstract

This report summarizes the key findings and highlights of the air monitoring program at the Erie Community Center (ECC) since its inception in October 2021. Citizens of Erie have expressed particular concern about air quality impacts from oil and gas extraction operations within and nearby Erie, especially those in Weld County. As such, this report focuses on air pollutants of particular interest to human health, including ozone, particulate matter (PM), and benzene. Additional compounds that are tracers for oil and gas operations are presented as well. The co-monitoring of meteorological conditions with pollutants allows a source analysis to be conducted, which is presented here. The National Ambient Air Quality Standard (NAAQS) for ozone was exceeded on 13, 3, and 20 days in 2022, 2023, and 2024, respectively. Comparison of these data to those of other monitoring stations maintained by Boulder AIR in Broomfield, Longmont, and Boulder are presented. Erie experiences similar levels of ozone, but significantly higher levels of other air pollutants comparted to neighboring Front Range communities. This includes the greenhouse gas methane, as well as harmful pollutants such as particulate matter (PM) and benzene. There is also indirect evidence that nitrogen oxide emissions and resulting ambient air concentrations are higher at Erie than in surrounding communities. The 24-hour NAAQS for PM2.5 was exceeded on 3 days. Short (~minutes) occurrences of PM, especially of PM10, were observed 2-10 times more often than in neighboring communities. Erie also received approximately 10 times as many benzene alerts compared to neighboring sites. A remarkable finding at ECC is the frequent occurrence of elevated VOCs that have signatures consistent with liquid petroleum fuel, such as gasoline, at concentrations that are approximately 100 times that of typical background levels seen in clean air. Methane, a potent greenhouse gas, doubled over background levels nearly 1700 times, approximately 4-8 times the number of occurrences seen at neighboring stations within the front range oil and gas footprint, some of which may be attributable to a nearby landfill source. The relatively higher occurrence of elevated levels in air pollutants raises concerns about the cumulative effects of exposure on the health and well-being of Erie residents.

1. Monitoring Overview

The photo of the monitoring station on the cover page of this report depicts the monitoring station located at the Erie Community Center (ECC), at 40.0402 °N, 105.0519 °W, 1538 m elevation. It was installed and began reporting in the fall of 2021. Monitored air pollutants include methane (CH_4), ozone (O_3), volatile organic compounds (VOCs), and particulate matter (PM). Additionally, meteorological conditions are observed, including wind velocity (i.e. speed and direction), solar radiation, temperature, humidity, and barometric pressure. All monitoring is automated and updates with 1 minute to 1 hour frequency. The pollutant monitoring follows regulatory protocols and requirements for instrumentation and calibration so that the data meet quality requirements that are stipulated regulatory agencies such as the Colorado Department of Public Health and Environment (CDPHE) and the Environmental Protection Agency (EPA). Additional details of calibration standards, instrumentation, and data quality control can be found at the Erie Air Quality Website (https://www.bouldair.com/erie.htm) and clicking on the "Methods" tab at the top of the page.

The website home page reports all of the above data in real-time and has had over 6322 visits as of 9 October 2024. The Erie data are also reported on the AirLive Combined Data web page (https://www.bouldair.com/NoCoFrontRange.htm), which shows data from all stations that are maintained by Boulder AIR in the Northern Colorado Front Range (NCFR) network for the past 30 days. This website has received over 17284 views. These websites have also become popular to the point of being used as a classroom tool in Colorado State University atmospheric science classes. Additionally, an interactive data analysis tool (IDAT) is available to enable quick analysis of pollutant time series from these stations (https://bouldairtools.com/interactive/).

The monitoring at ECC is part of a larger network owned by local governments in a coalition between Erie, Longmont, Boulder County, and Broomfield. Other air quality monitoring stations within this network include Longmont Union Reservoir (LUR), Longmont Lykins Gulch (LLG), Broomfield Soaring Eagle (BSE), Broomfield North Pecos (BNP), and Boulder Reservoir (BRZ). This coalition, known as the Front Range Local Government Coalition, was formed in response to overwhelming concerns from citizens about the regional air quality degradation resulting from the increase in oil and natural gas (O&NG) production, particularly unconventional drilling and hydraulic fracturing ("fracking") in Weld County. To our knowledge, this is the only case in the United States where local governments have unified to fund an air quality network of this scale. Data from the regulatory-grade instruments in this network fill a critical spatial gap in coverage from CDPHE monitoring. Their joint efforts have made important contributions in improving the identification of air pollution sources and transport, and in directing the State's policy and rules making for reducing pollution emissions and improving air quality.

2. Selected Pollutants and Data Interpretations

2.1. Ozone

Ozone is not a directly emitted pollutant. It is formed in the atmosphere by a chain of photochemical reactions that involve sunlight, nitrogen oxides, and volatile organic compounds (VOCs), which therefore are considered crucial precursor emissions that impact ozone production and maxima, and degradation of air quality. The National Ambient Air Quality Standard (NAAQS) for the maximum daily 8-hour average ozone mixing ratio (MDA8) was lowered to 70 parts per billion (ppb) in 2015 in recognition of the insufficient protection of human health with the previous standard that was set to 75 ppb in 2008. In 2022, the Northern Colorado Front Range (NCFR) was further downgraded to a *severe* nonattainment area for the 2008 NAAQS standard (after previously having been designated a *serious* nonattainment area for ten years) because of the continuing high summertime ozone conditions and lack of air quality improvements. Ozone monitoring data over 8 hours are averaged and truncated, therefore, 8-hour average mixing ratios must be >70.9 ppb and >75.9 ppb to be considered above the 2015 and 2008 standards, respectively. Attainment to the standard is determined by the 3-year mean of the 4th-highest 8-hour average. Both standards are observed by the EPA when designating non-attainment status to urban areas or air basins.

Table 1 shows the number of ozone exceedance days that have been observed each year at the Erie Community Center (ECC) monitoring station for both the 2015 and 2008 standards. Comparison to other monitoring stations maintained by Boulder AIR within the NCFR are also shown. In total, Erie experienced 36 (18) days between 1 January 2022 and 16 August 2024 when the 2015 (2008) standards were exceeded. This roughly compares to the number of ozone exceedances seen at BSE, LUR, and LLG during this period. 2024 has been a particularly prominent ozone season for the entire NCFR, including Erie, which experienced 20 exceedance days. The 4th-highest value is well above the 2008 and 2015 standards. If this were to be repeated over three years, these recordings would be well above the NAAQS and continue the area being in violation of the Clean Air Act. It is important to note that ozone is a region-wide phenomena, and thus its concentration tends to be more uniform across an air basin compared to that of other pollutants which are more affected by local sources and sinks.

Table 1. Number of ozone exceedance days per year for the 2015 (2008) NAAQS standards for Erie Community Center (ECC) compared with four other stations that are operated by Boulder AIR under contract with local governments: Boulder Reservoir (BRZ), Broomfield Soaring Eagle Park (BSE), Longmont Lykins Gulch (LLG), and Longmont Union Reservoir (LUR). The highest readings from each station from each year is shown in red.

Number of NAAQS Exceedance Days

Year	ECC	BRZ	BSE	LLG	LUR
2022	13 (4)	9 (2)	**15 (4)**	12 (2)	17 (6)
2023	3 (1)	4 (1)	5 (1)	4 (1)	**11 (2)**
2024 [a]	20 (13)	-	**25 (13)**	18 (10)	23 (12)
Total	36 (18)	-	45 (18)	34 (13)	51 (20)

[a] 1 Jan - 30 Sep

The comparison of ozone at Erie to other NCFR sites can also be seen with the box-and-whisker plots shown in Figure 1. The mean values, as well as all percentile values, are similar between Erie, Broomfield, and Longmont for each month of the year. The highest ozone in the NCFR occurs from May through August, with lower values in the winter. The particularly low percentile values at ECC suggest the presence of relatively higher levels of NO_x at ECC compared to the other sites. At night, nitric oxide (NO) destroys ozone, counter to the role of nitrogen oxides in ozone production during the day [1, 2]. Therefore, the lower nighttime ozone values at ECC are indicative of higher NO_x emissions than at the other monitoring stations. NO_x emission arise primarily from combustion, such as vehicle engine and building natural gas or oil furnace exhaust. NO_x is currently not monitored at ECC, so there are no direct measurements to support this hypothesis.

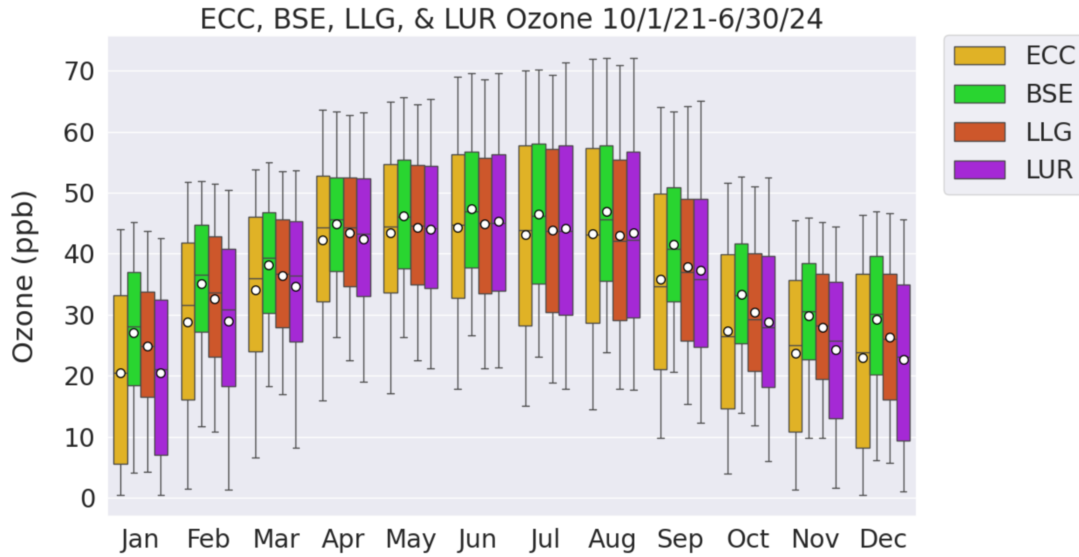

Figure 1. Box-whisker plots for ozone at ECC compared to BSE, LLG, and LUR for 1 October 2021 – 30 June 2024, binned by month of year. The boxes represent the 25^{th} – 75^{th} percentile ozone mixing ratios and the whiskers represent the 5^{th} and 95^{th} percentiles. The white dots show the mean. Similar ozone levels are observed at each site, with summer months showing the highest values.

Bivariate polar plots depict observed quantities of monitored chemicals as colors, plotted by wind direction and speed. Red colors indicate higher levels of the monitored chemical, whereas blue colors represent lower levels. The figure acts as a compass of wind direction with ECC located at its center. Wind speeds are monitored in meters per second (m/s) and increase radially from the center. This technique aggregates data into wind speed and direction bins and uses the chemical's median value in each bin to color the figure. As such, the colors shown should not be interpreted as the maximum concentrations observed for a given chemical. The minimum bin ("min-bin") parameter specifies the minimum number of values in each wind speed and direction bin needed to be considered in the interpolation and shown in the figure. Gray areas on the figure represent data that have been removed because there were too few data points in the particular bin to meet the min-bin threshold. It is also important to note that data with wind speeds less than 1 m/s are excluded from this analysis to ensure clear wind direction dependency results.

Figure 2 shows a bivariate polar plot for ozone during the summer season, averaged over June – August 2022-2024, from 12:00 – 20:00 MST, when ozone typically reaches its daytime maximum. Ozone levels are highest in air transported from the northeast, aligning with the area of most dense O&NG activities in Weld County. Some higher ozone conditions also occur in transport from the south, likely caused by photochemical reactions involving emissions in the Denver Metro area. In contrast, much (~10-15 ppb) lower ozone is observed when air is transported from the west of Erie.

Elevated ozone can have serious health, environmental, and regulatory consequences. Elevated ozone levels worsen respiratory illnesses like asthma and bronchitis, particularly for vulnerable groups such as children and the elderly [3, 4]. Environmentally, high ozone damages ecosystems by harming forests [5] and decreasing crop yield [6]. If the NCFR fails to lower ozone levels in future seasons, it risks being reclassified to a more severe non-attainment status under the 2015 standard, leading to even stricter emission controls and more regulatory pressure to reduce ozone-forming pollutants.

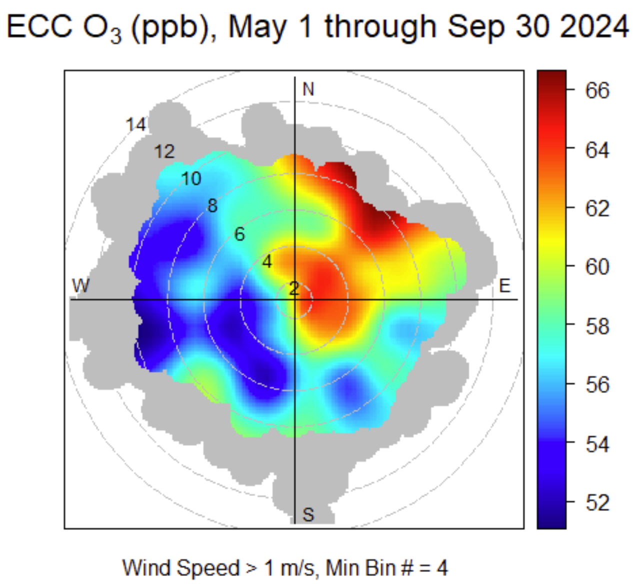

Figure 2. Bivariate polar plot showing the dependency of ozone at ECC as a function of wind speed (m/s) and wind direction, with the color scales indicating median ozone mole fraction for a given wind speed and direction. The orientation of the data reflects the wind direction on a 360-degree circular compass, and the concentric rings from the center the wind speed. The color indicates the median observed ozone in ppb according to the color bar scale in the legend. The highest ozone is being transported to ECC from the northeast, where oil and gas drilling activities are most dense.

2.2. Particulate Matter (PM)

Particulate matter consists of tiny solid-phase aerosols suspended in the air. It is classified by particle size, as smaller aerosols can penetrate deeper into the lungs and cause more tissue damage [7] and adverse health effects. In 2006, the US EPA adopted a NAAQS for particulate matter of 10 micrometers or smaller in diameter (PM 10) of 150 micrograms per cubic meter (µg/m^3), and 35 µg/m^3 for PM 2.5, both for PM data averaged over 24 hours.

During the monitoring period at ECC (1 Oct 2021 – 25 Sep 2024), there have been on the order of 10,000 occurrences when these threshold values were exceeded for short (minutes to hours) episodes. There have been three days when the 24-hour average PM 2.5 NAAQS of 35 µg/m^3 was exceeded. These three days occurred consecutively from 19 – 21 May 2023. This pollution was caused by smoke from Canadian wildfires that was transported to Colorado during this time. A time series of 1-minute PM 2.5 concentration readings during this event is shown in Figure 3. The highest 24-hour average concentration at ECC was observed on 20 May (95.9 µg/m^3), approximately 2.5 above the NAAQS. The Erie peak value was highest compared to the peak 24-hour average concentrations at LUR (87.9 µg/m^3) and BSE (92.3 µg/m^3).

Figure 3. Time series graph of PM 2.5 (1-mintue data) from 18-27 May 2023 for Erie (yellow), Longmont (pink), and Broomfield (green). The Canadian Wildfire smoke event is shown with the shaded box. The 24-hour average NAAQS is shown with the orange horizontal line.

Average PM concentrations binned by month and compared to BSE and LUR are shown in the box-and-whisker plot in Figure 4. Average concentrations are higher at ECC than at BSE and LUR, particularly for PM 10, where the mean values are nearly twice as high compared to the other stations. Counts of 1-minute occurrences (*not* 24-hour averages) that exceed 100 µg/m^3 for both PM 2.5 and PM 10 at these stations are shown in Table 2. For each year except 2024, ECC observed the highest number of PM 2.5 spikes. The issues of elevated PM spikes in Erie become especially apparent in the count of PM 10 spikes; each year, ECC consistently observes between 2-10 times the number of spikes as BSE and LUR.

Table 2. Number of 1-minute occurrences when PM 2.5 and PM 10 was > 100 µg/m^3 for Erie Community Center (ECC) compared with Broomfield Soaring Eagle Park (BSE) and Longmont Union Reservoir (LUR). The highest station from each year is shown in red.

Number of times PM > 100 µg/m^3

	PM 2.5			PM 10		
Year	**ECC**	**LUR**	**BSE**	**ECC**	**LUR**	**BSE**
2021 [a]	**70**	16	12	**3830**	781	453
2022	**188**	29	17	**3471**	1281	803
2023	**573**	132	142	**4777**	465	943
2024 [b]	67	**313**	2	**2748**	1435	129
Total	898	490	173	14826	3962	2328

[a] 1 Oct - 31 Dec
[b] 1 Jan - 30 Sep

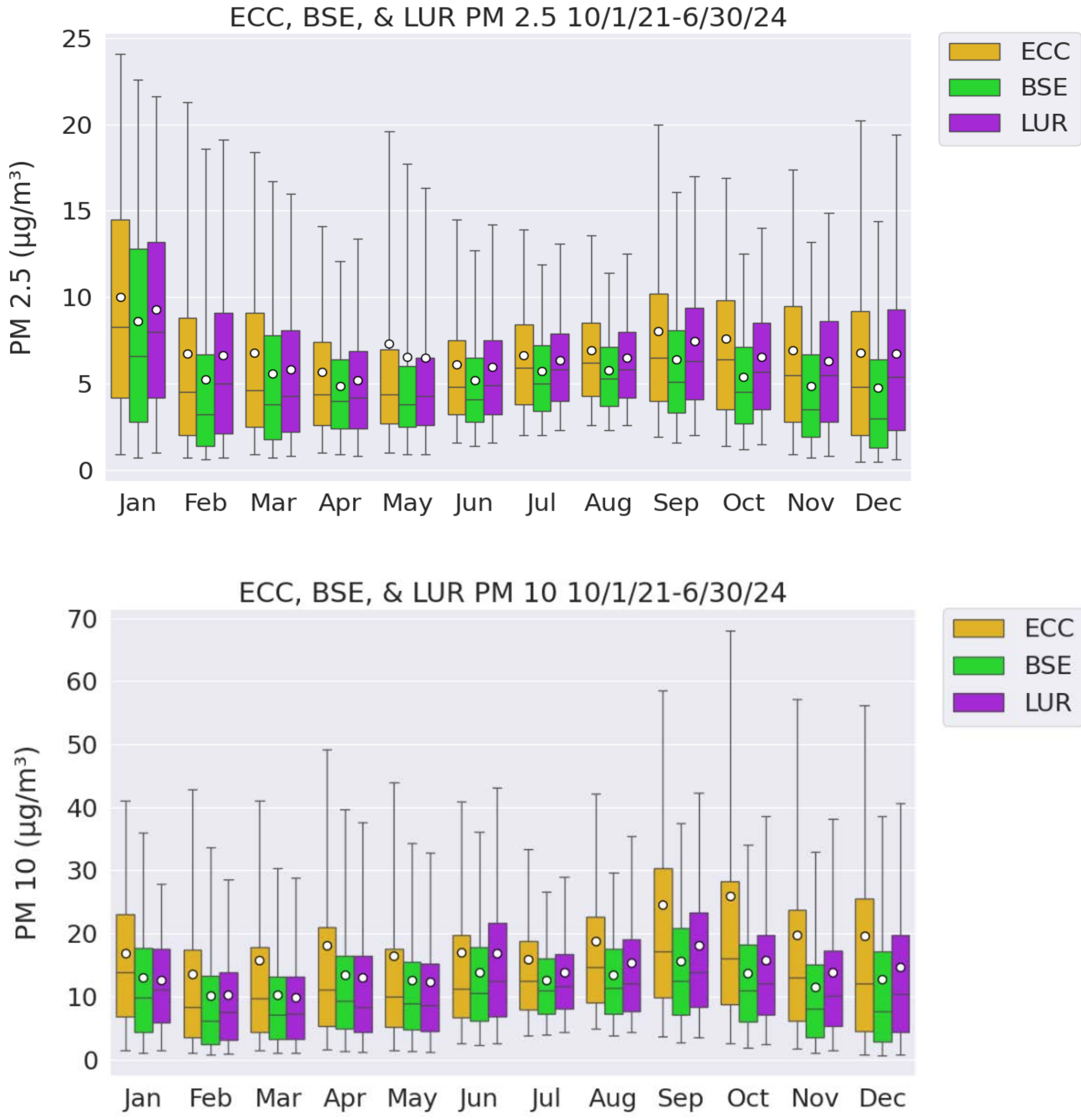

Figure 4. Box-whisker plots for PM (top: PM 2.5, bottom: PM 10) at ECC compared to BSE, LLG, and LUR for 1 October 2021 – 30 June 2024, binned by month of year. The boxes represent the 25th – 75th-percentile values and the whiskers represent the 5th and 95th percentiles. The white dots show the mean. PM concentrations, especially PM 10, are significantly higher at Erie compared to neighboring sites.

2.3. Benzene

In response to citizens of Erie's particular concerns about air toxins emitted from oil and natural gas (O&NG) operations within and on the outskirts of the community, we have been analyzing benzene levels since the start of the monitoring program. Benzene is one of the most widely studied hydrocarbons, and the US Environmental Protection Agency (EPA) designates it as a pollutant that from inhalation can cause chronic health effects and cancer [8-10].

Figure 5 shows a box-and-whisker plot of benzene at Erie compared to BSE, BNP, LUR, and BRZ, binned by month. The format is identical to Figures 1 and 4, but instead here we show the whiskers as the 1st and 99th percentile values to better capture observed concentration spikes. Median benzene levels at Erie are approximately 30-60% higher than in the NCFR neighboring towns for all months of the year and are a particular concern in the winter when atmospheric mixing is suppressed. During December and January, the highest 1% of benzene observations exceed 0.9 ppb, which is the threshold that Boulder AIR uses for automated alerts. It corresponds to the California Office of Environmental Health Hazard Assessments maximum threshold at which there are no known non-cancerous chronic health impacts if an individual breathes this amount of benzene for up to a lifetime. The maximum benzene level that has been observed during the monitoring program at ECC was 8.2 ppb, which was higher than at BRZ (2.3 ppb), BSE (4.4 ppb), and LUR (4.8 ppb), but lower than one event at BNP (14.7 ppb) during this time. Table 3 shows the number of occurrences when benzene exceeded 0.9 ppb during the Erie observation period. For each year except 2021, the highest number of benzene alerts has been recorded at ECC. In 2022 and 2023, the number of benzene alerts recorded at Erie was about 2 to 3 times higher than at the second-highest reporting station during those years, and approximately 10 times higher than the median number of occurrences at other sites.

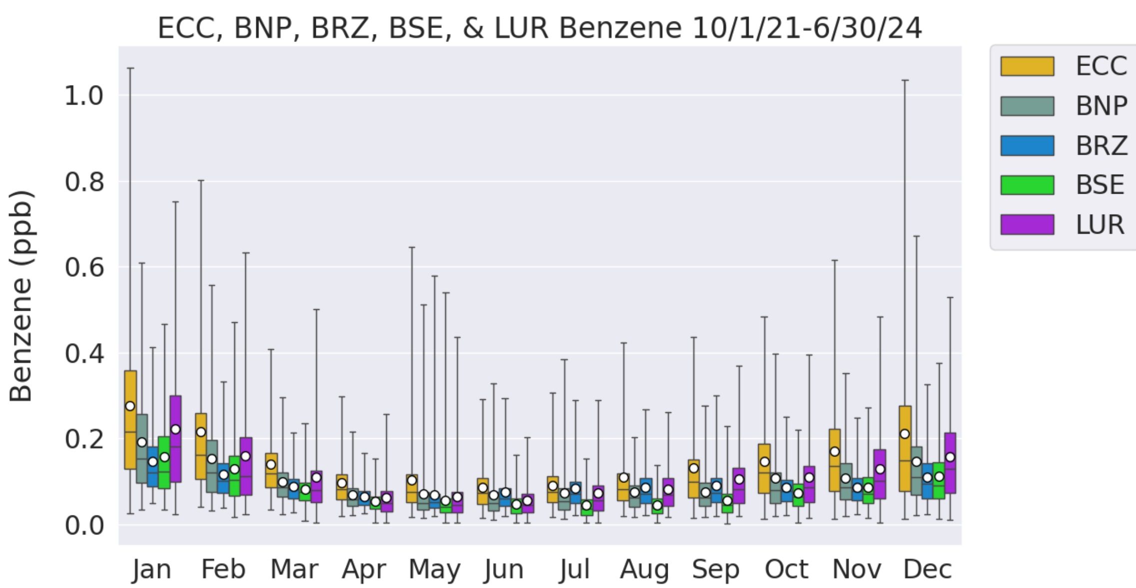

Figure 5. Box-whisker plots for benzene at Erie (ECC) compared to Broomfield (BSE, BNP), Boulder (BRZ), and Longmont (LUR) for 1 October 2021 – 30 June 2024, binned by month of year. The boxes represent the 25th – 75th percentile ozone mixing ratios and the whiskers represent the 1th and 99th percentiles. The white dots show the mean. Erie observes higher benzene than neighboring sites, and the 99th percentile exceeds the alert threshold (0.9 ppb) in December and January.

Table 3. Number of times benzene exceeded 0.9 at ECC, LUR, BRZ, BNP, and BSE. The highest number from each year is shown in red.

	Number of times benzene > 0.9 ppb				
Year	**ECC**	**LUR**	**BRZ**	**BNP**	**BSE**
2021 [a]	5	1	0	17	3
2022	55	28	4	9	1
2023	51	4	4	15	1
2024 [b]	11	9	1	0	0
Total	122	42	9	41	5

[a] 1 Oct - 31 Dec

[b] 1 Jan - 30 Sep

Figure 6 shows a bivariate polar plot for benzene at ECC. Enhanced median values of benzene are mostly associated with light winds (< 2 m/s). Some possible local sources include but are not limited to vehicular traffic, building emissions, local gas stations, or emissions from O&NG wells. Overall, the right half of the compass (wind directions from the easterly sector) is associated with higher benzene levels, which is consistent with the O&NG footprint in Weld and Adams counties, although it is important to remember that benzene has many additional sources. The enhanced benzene values associated with easterly winds > 6 m/s are consistent with the enhanced ethane found at similar wind velocities (discussed in section 2.4), which may be more suggestive of possible O&NG sources.

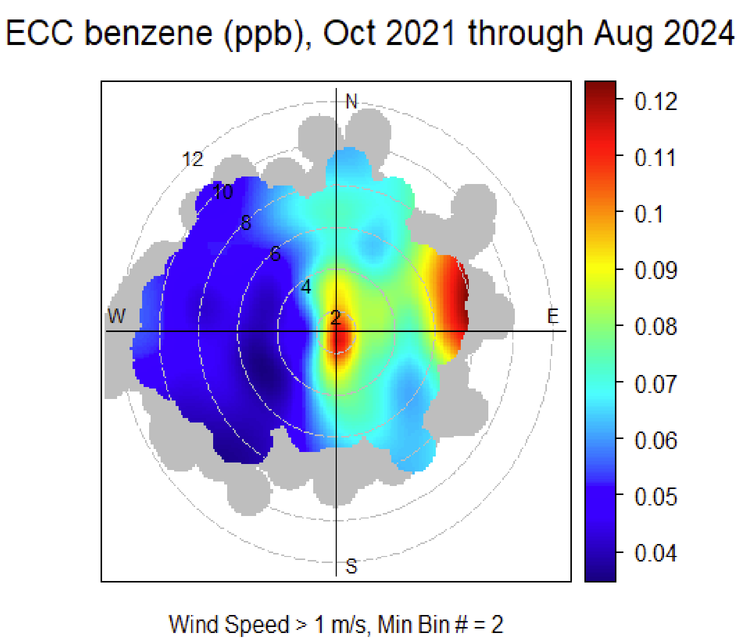

Figure 6. Bivariate polar plot showing the dependency of benzene at ECC as a function of wind speed (m/s) and wind direction. The highest benzene is observed when winds are blowing from the north to south, and at higher wind speeds from the east.

It is important to note that these benzene values are only reflective of a 10-minute sample taken each hour at a single location (ECC) and do not necessarily reflect maximum concentration levels that might be observed in residential areas that are closer to the respective sources. Shorter duration measurements (e.g. 1-minute) or even 10-minute concentrations between the observation windows or at other nearby residential locations, are likely higher.

2.4. Methane

Methane and light alkanes (ethane, propane, butane, and pentane) are natural gas constituents, which are frequently observed in ambient air within the NCFR in O&NG plumes [11-14]. Methane enhancements above background (~2 parts per million (ppm)), can sometimes be suggestive of plumes that originated from leaking wells or pipelines. However, it should be noted that methane has additional non-O&NG sources, including landfills and agriculture [15-18]. Table 4 shows the number of 1-minute methane observations exceeding 5 ppm at Erie during the whole monitoring period, compared with LUR, LLG, and BNP. Erie experienced approximately 2.7 times the total number of elevated methane observations exceeding this threshold than at Longmont and Broomfield combined, suggesting more and stronger methane sources in proximity to ECC compared to these other sites. A bivariate polar plot of methane (Figure 7) suggests that the highest values primarily occur during light winds, suggesting nearby sources. Enhanced methane at ECC is particularly observed with east-southeasterly winds between 5 and 10 m/s. It is likely that these elevated methane plumes are originating from the Front Range Landfill 3.2 km to the east-southeast of ECC.

Table 4. Number of times methane exceeded 5 ppm at ECC, LUR, LLG, and BNP. The highest number from each year is shown in red.

	Number of times methane > 5 ppm			
Year	**ECC**	**LUR**	**LLG**	**BNP**
2021 [a]	84	22	0	**97**
2022	**582**	124	0	96
2023	**814**	50	0	222
2024 [b]	**216**	10	2	5
Total	1696	206	2	420

[a] 1 Oct - 31 Dec

[b] 1 Jan - 30 Sep

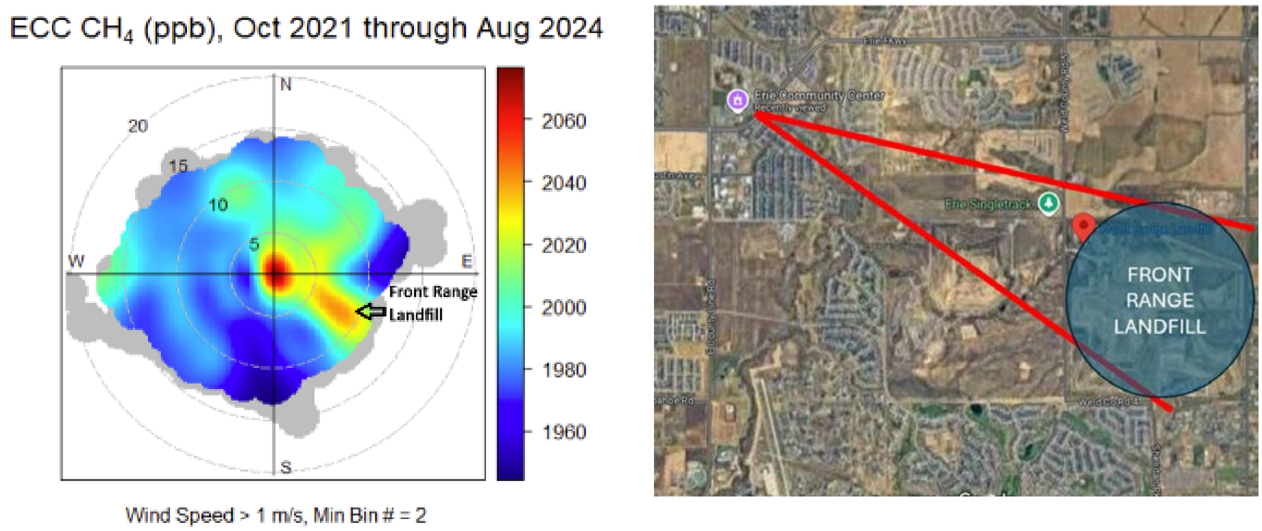

Figure 7. Bivariate polar plot showing the dependency of methane at ECC as a function of wind speed (m/s) and wind direction. Elevated methane is primarily transported from the northeast sector and a more narrowly defined southeasterly direction that aligns with the upstream direction of the Erie Front Range Landfill.

2.5. Other Non-Methane Hydrocarbons

Unlike methane, which has many source categories, ethane is a more selective tracer of emissions from O&NG operations [19-22]. A bivariate polar plot for ethane (Figure 8) shows a more well-defined enhancement in the O&NG sector compared to the methane plot in Figure 7. In

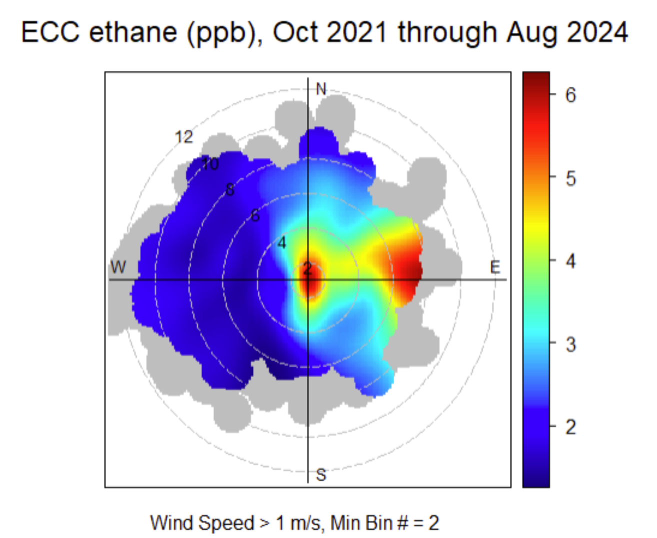

Figure 8. Bivariate polar plot showing the dependency of ethane at ECC as a function of wind speed (m/s) and wind direction. Elevated ethane is mostly transported to the station in air originating from the northeast to southeast direction, with a consistent predominance of elevated ethane in air during high wind speed conditions from the east.

particular, strong east to north-northeasterly winds between 8 and 10 m/s are associated with enhanced ethane mixing ratios, which is consistent with the direction where the highest density of O&NG wells are in relation to ECC.

In addition to ethane, the influence of O&NG operations on chemical composition in atmospheric plumes can be inferred from an analysis of the ratio of two VOCs, specifically that of isomeric i/n-pentane, as ratio values characteristic of O&NG emission sources typically fall between approximately 0.75 and 1.2 [19-22]. Figure 9 shows a bivariate polar plot for the isomeric pentane ratio as observed in the ECC data. Air arriving at ECC has distinctly different signatures depending on where it originates. Transport from the south to west is associated with ratios > 1.3, which likely is reflective of urban emission and gasoline sources in the Denver metropolitan region. In contrast, air transported from the northeast clearly shows values < 1.2, consistent with the O&NG emissions originated in the Weld County sector.

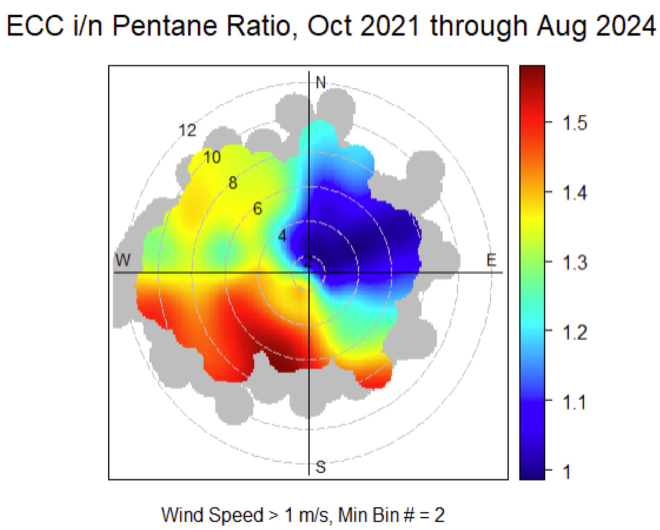

Figure 9. Bivariate polar plot showing the dependency of the isomeric pentane ratio at ECC as a function of wind speed (m/s) and wind direction. Ratio values consistent with oil and natural gas (O&NG) sources are observed when winds are blowing from the northeast, and ratio values consistent with mobile sources are observed from the south and southwest.

2.6. Gasoline VOCs Spikes

During the monitoring period at ECC, a strikingly high number of high VOCs events occurred during evening hours, which were not observed at other NCFR stations. Figure 10 shows a time series of i-pentane at several NCFR stations with ECC shown in yellow. In total, there were 18 occurrences of i-pentane > 50 ppb at ECC, whereas only 6 of these occurrences were observed at LUR and none observed at BRZ. The peak concentrations in these i-pentane spikes at ECC are approximately 100 times that of background levels. These events consistently occur in evenings between 19:00 and 22:00 MDT. The plumes in these back-trajectories were also associated with enhanced n-hexane and n-butane approximately 10-100 times background levels, but no enhancement of ethane. This unique combination of VOCs, lacking natural gas VOCs and containing mid-volatile liquid petrochemical hydrocarbons suggest a gasoline fuel source.

While bivariate polar plots are powerful source analysis tools when ample data are available, they are not able to adequately analyze single, isolated events. As such, we employ a simple back-trajectory analysis which takes the wind speed and direction information at ECC and infers the route the parcel of air traveled in the 15 minutes prior to arriving at the monitoring station.

15-mintue back trajectories of 8 selected events are shown in Figure 11. The consistency of air transport from the south-southwest corresponding with the pentane spikes strongly suggests a fixed-point source of these plumes, as opposed to a mobile source. This is a concerning finding, as residents living closer to the source are likely exposed to higher concentrations than seen at ECC. Of note is a Shell fueling station 700 m south-southwest of ECC. While we cannot be certain that this is the source of these anomalous plumes, we note that in 7 of 8 cases, transport from the south or south-southwest was occurring. Also note that these back-trajectory models are dependent on wind measurements at a single location and have limited precision for defining the location of an emissions source at a larger upwind distance.

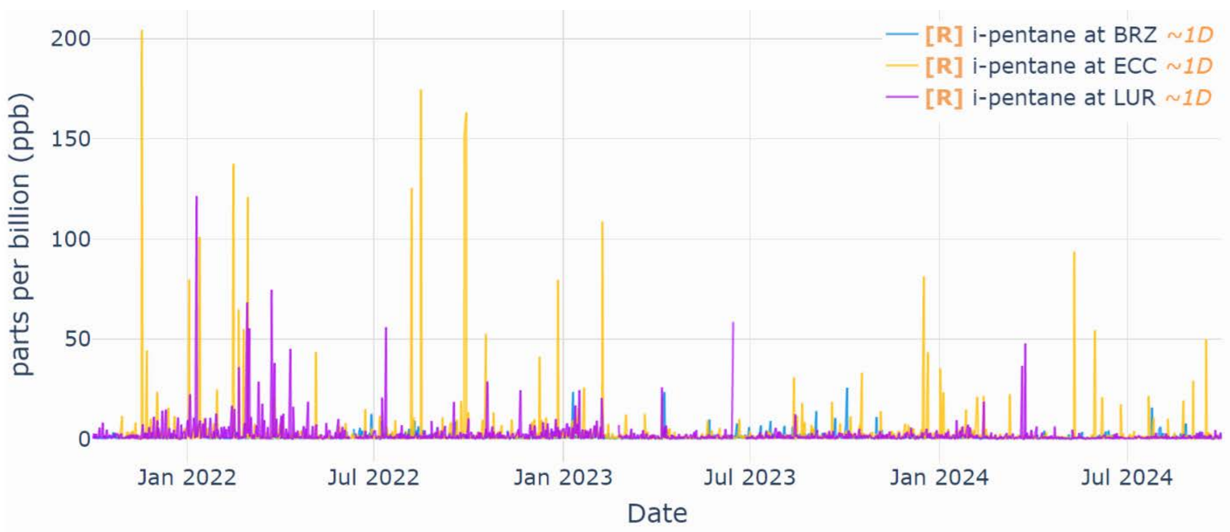

Figure 10. Time series of iso-pentane at three NCFR sites from 1 Oct 2021 – 30 Sep 2024. ECC observes numerous spikes that are consistent with a gasoline source, which is not observed at such a high frequency at LUR or BRZ.

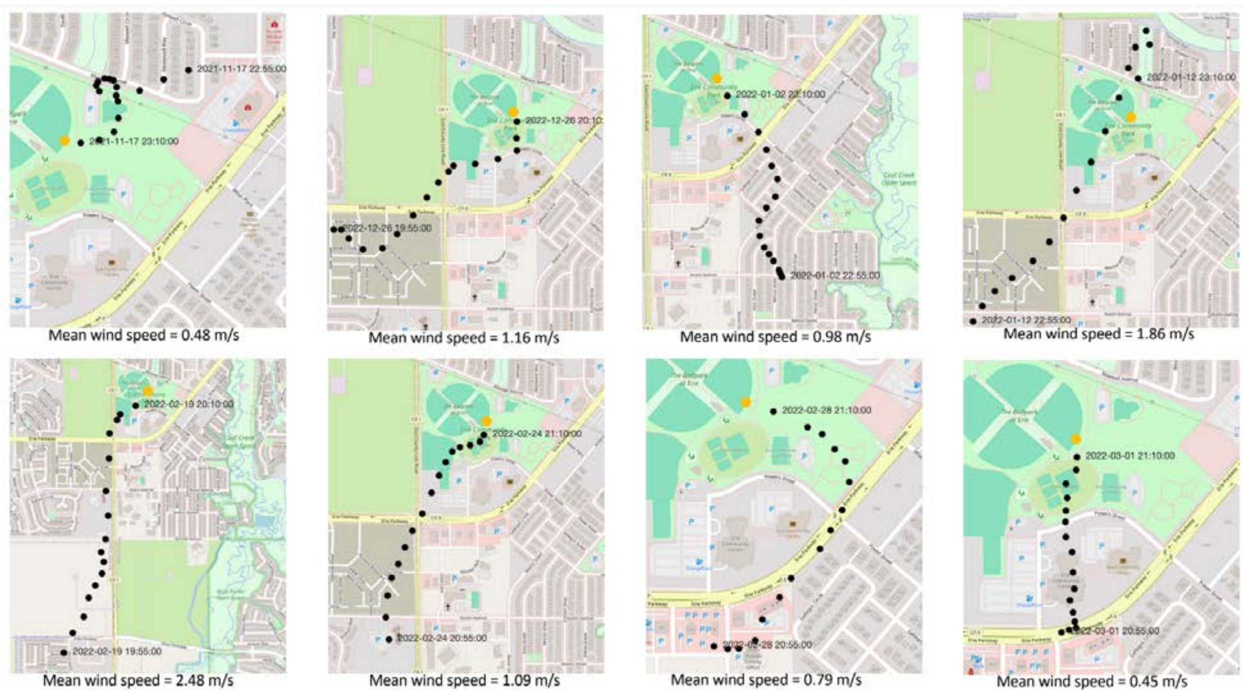

Figure 11. 15-minute back-trajectories for 8 selected events of nocturnal spikes of heavy alkanes (butane, pentane, and/or hexane). Each black dot represents a 1-minute increment on the inferred pathway that the air parcel took before arriving at ECC.

3. Conclusions

The air quality monitoring program at the Erie Community Center has uncovered that Erie consistently experiences the highest levels of air contaminants among NCFR comparison sites. Notably, there is no air monitoring conducted in Erie by CDPHE, making the data from this monitoring program the only resource and crucial for understanding local air conditions. Key findings include:

(1) Ozone levels at Erie are similar to those of other NCFR sites. Ozone levels at Erie have been exceeding the ozone NAAQS in every year since the onset of the monitoring, peaking in 2024 with 20 days when the 70 ppb ozone NAAQS was exceeded.

(2) Inferred NO_x levels appear to be higher at Erie than at surrounding sites as implied by the low percentile ozone values. This suggests that Erie is more heavily influenced by fuel combustion exhaust than neighboring communities. NO_x is not currently monitored directly at ECC.

(3) Events with increased particulate matter, in particular PM 10 spikes of at least 100 µg/m^3, occur between 2 and 10 times more frequently in Erie compared to Broomfield and Longmont.

(4) Benzene spikes of at least 0.9 ppb occur about 10 times more often at Erie than surrounding NCFR sites, exceeding the alert threshold (0.9 ppb) in at least 1 in 100 hourly observations during December and January.

(5) Methane enhancements exceeding 5 ppb occur approximately 4 and 8 times more often at Erie than at Broomfield and Longmont sites. Besides elevated emission from within the O&NG footprint, the landfill to the south-southeast appears to be another source of these high methane occurrences.

The findings highlighting Erie's air quality concerns—such as a high number of ozone health standard exceedance days, higher inferred NOx levels, more frequent particulate matter spikes, significant benzene exceedances, VOCs gasoline plumes, and methane enhancements Neither the state (CDPHE) nor the EPA are conducting air quality monitoring in Erie. This research has exclusively built on Erie's support for the ECC air monitoring program which has made these detailed observations possible.

The air quality data from ECC, together with the monitoring program in the neighboring communities (Boulder, Longmont, Broomfield) have become the foundation for research programs on Colorado Front Range air pollution. Data have been requested and are being shared regularly with researchers from universities, NOAA, and the National Center for Atmospheric Research.

A number of grant proposals have been developed by Boulder AIR and partnering researchers building on the ECC data for in-depth studies of specific aspects of NCFR air quality. These projects have been awarded:

"Air quality trends in Texas and Colorado as associated with unconventional oil and gas development (UOG)"; submitted by Texas A&M University and Boulder AIR, with funding received from the Health Effects Institute (HEI), 2024.

"Comprehensive Ozone Source Location Analysis"; submitted by the Local Air Monitoring Coalition with funding received by the Colorado Air Quality Enterprise, 2024.

"How much of the Denver Metro Northern Front Range Ozone is Produced from Isoprene?"; submitted by Boulder AIR with funding received by the Colorado Air Quality Enterprise, 2024.

In addition, this grant application is currently under review:

"Colorado Coalition of Local Governments Oil and Gas Methane Monitoring and Mitigation Program", submitted by the Colorado Coalition of Local Governments to the Department of Energy (DOE) Methane Emissions Reduction Program (MERP), 2024.

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