Selected results from Air Quality Research in the Carlsbad, NM, area

New Mexico Radioactive and Hazardous Materials Committee meeting, September 13, 2024

Detlev Helmig, Boulder AIR
Gunnar W. Schade, Department of Atmospheric Sciences, Texas A&M University

Study Objectives

Our study is designed to better understand emissions and population exposure to air pollutants coming from Unconventional Oil and Gas Development (UOGD)

1) Use fixed-placed, active air quality monitoring to characterize the emissions and impacts from UOGD (stationary trailer)

2) Use distributed, passive sampling to understand the potentially uneven distribution of selected toxic air pollutants (volunteer-driven)

3) Focus on UOGD related flaring by combining our measured data with satellite observations

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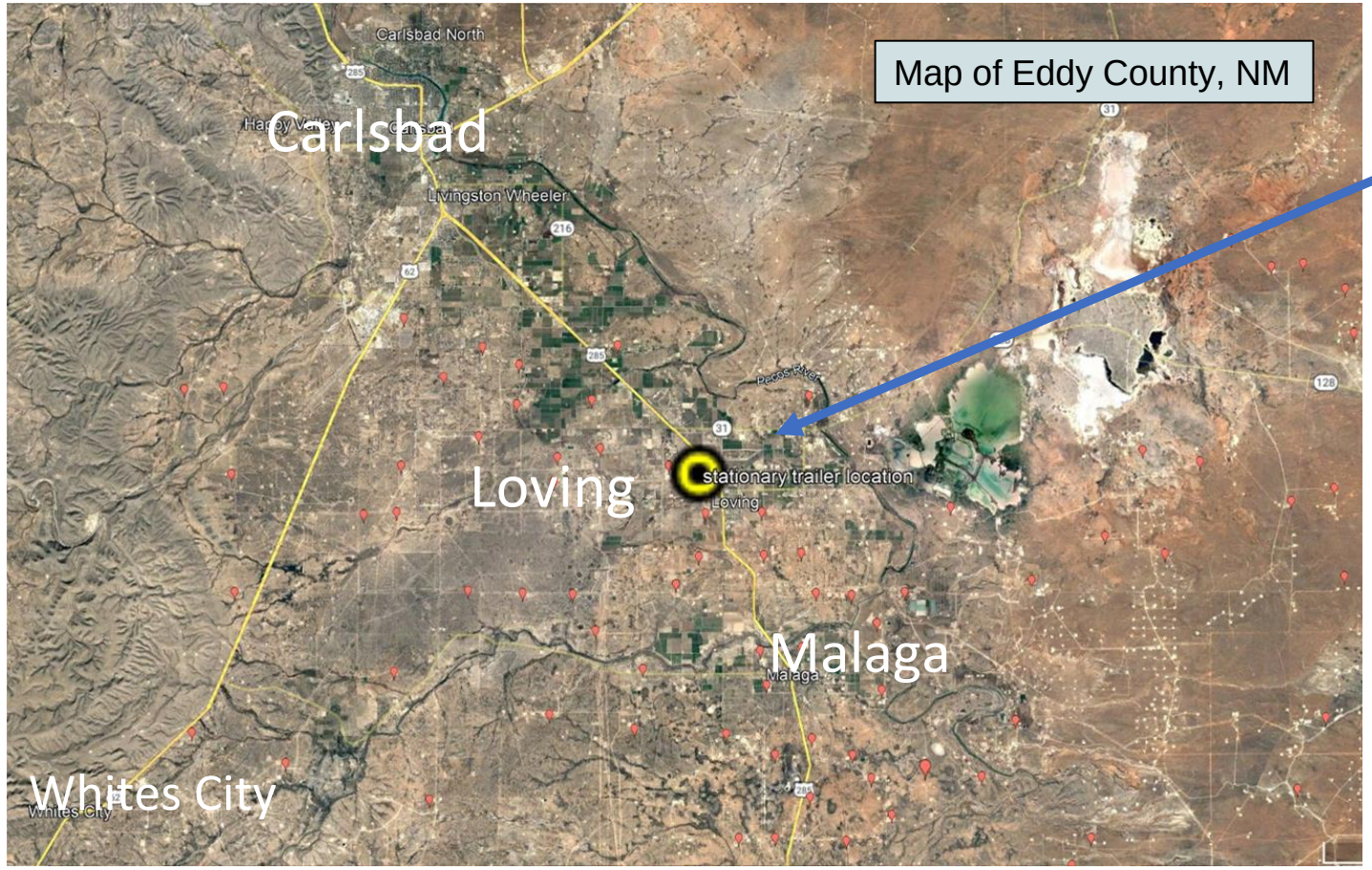
Overview of sampling site in Loving, NM



Stationary monitoring trailer location

Project website with real-time data reporting:

https://bouldair.com/loving.htm

(currently suspended)

Overview of stationary monitoring

- One year duration, started in April 2023
- Highly sensitive, <u>regulatory rated</u> instruments and protocols
- Fully automated, 24/7 operations
- Most extensive (# of monitored pollutants, # of measurements) air monitoring in New Mexico

What we are measuring in Loving, NM

Air Pollutants and Greenhouse Gases

- ***Ozone (O_3)***
- Volatile organic compounds (VOCs), 24 species, incl. *ethane*, propane, … acetylene, BTEX, ….
- Nitrogen Oxides (NO_x)
- Sulfur Dioxide (SO_2)
- Hydrogen Sulfide (H_2S)
- Carbon Monoxide (CO)
- *Methane (CH_4)*
- Carbon Dioxide (CO_2)

Radioactivity

- *Radon (Gas)*
- *Radon decay products (Particles)*

Noise

- Decibel levels at different frequencies

Ozone forms from:

- **VOCs as the fuel**
- **NO_x as the catalyst**
- **Sunlight as the driver**

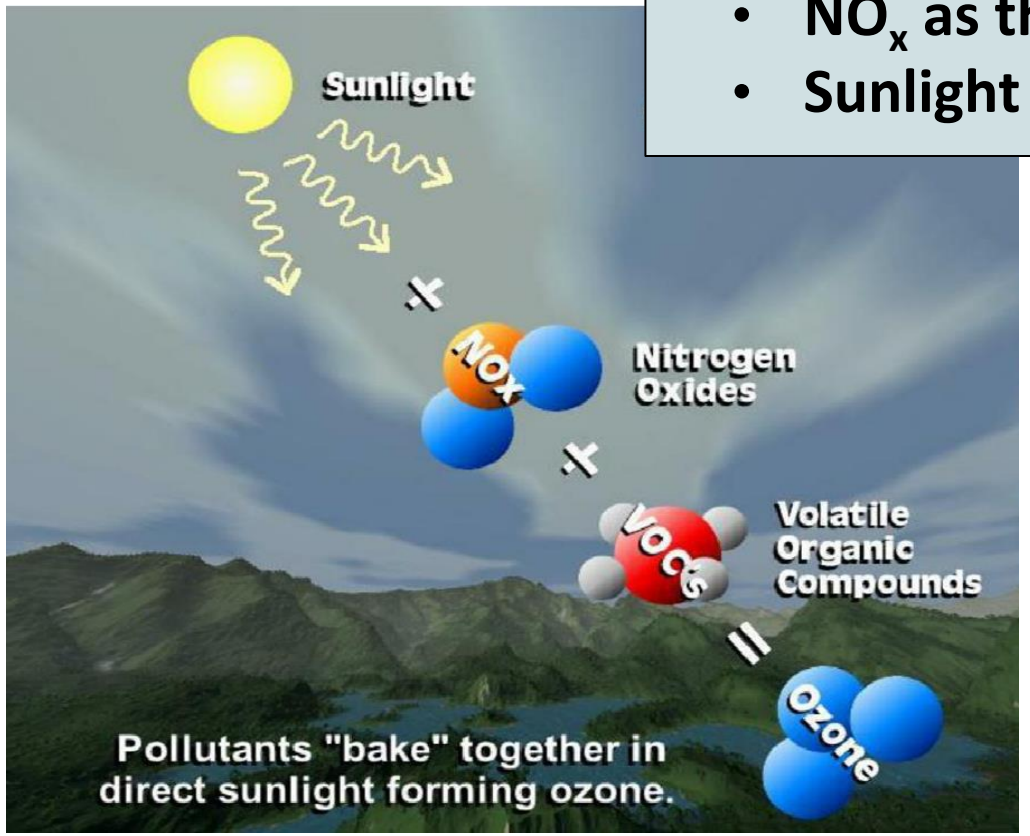


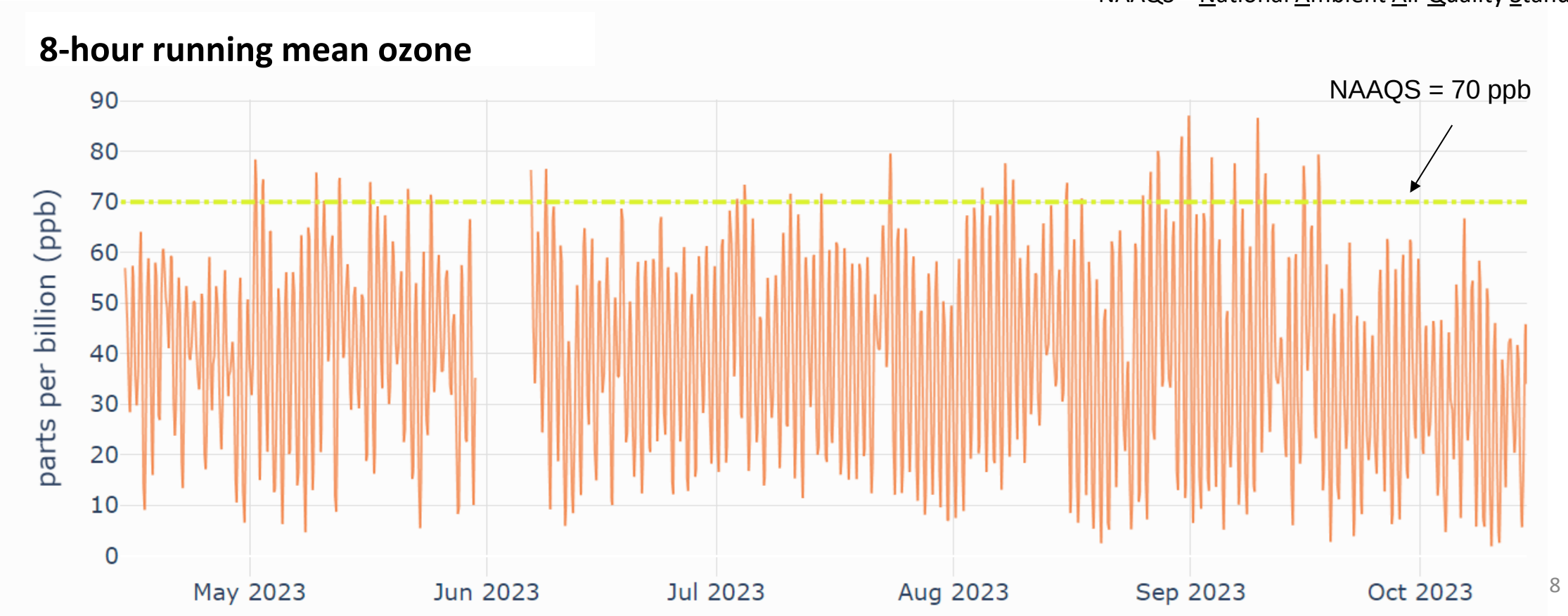
image credit: NASA/NSF

Ozone

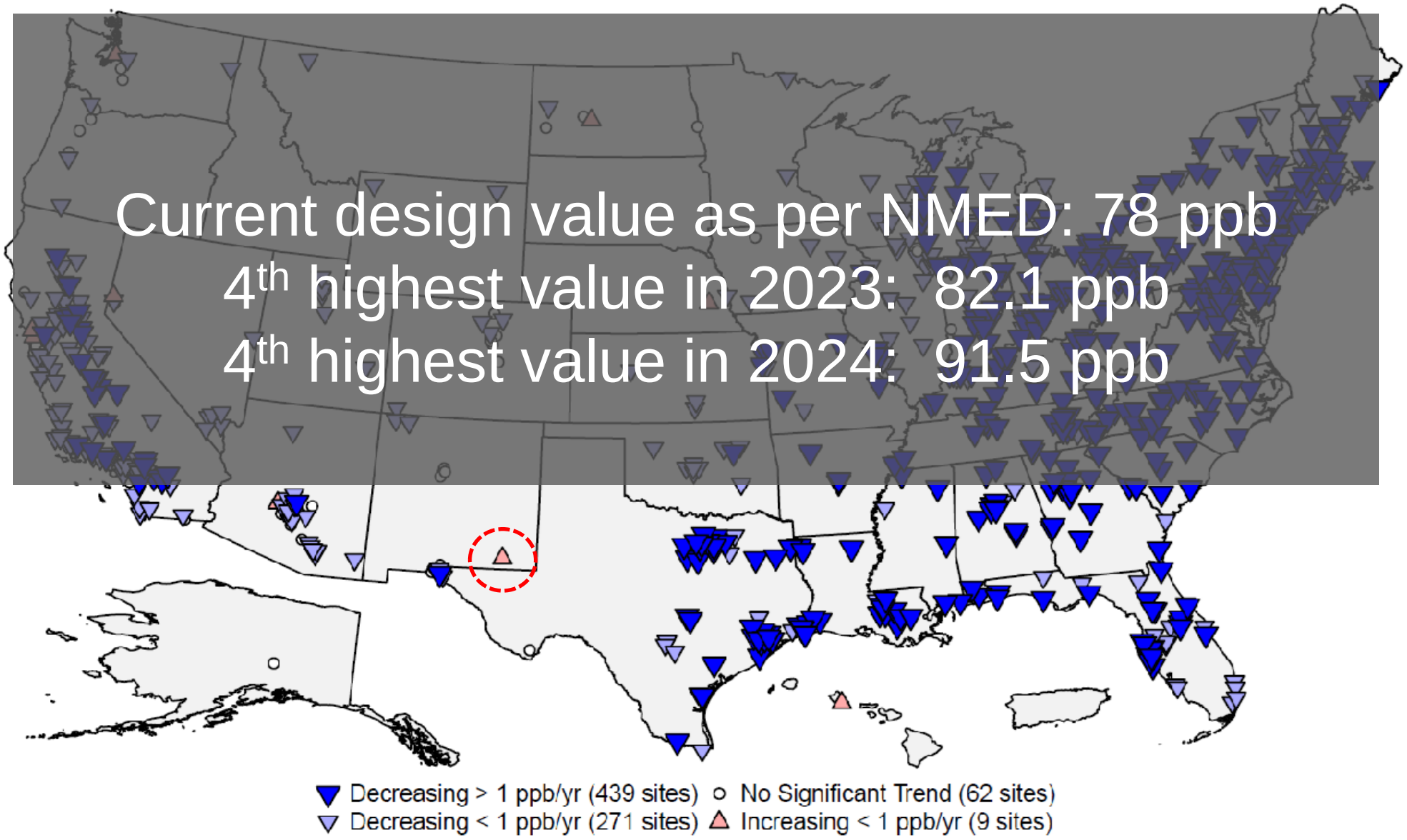
Ozone at the Loving, NM site

Ozone levels exceeded the U.S. EPA 8-hour NAAQS* of **70 ppb** on ***31 of 155*** days in 2023.
(Exceedances so far have occurred on 40 days in 2024)
Similar exceedances have been observed for several years at Carlsbad Caverns.

* NAAQS = National Ambient Air Quality Standard

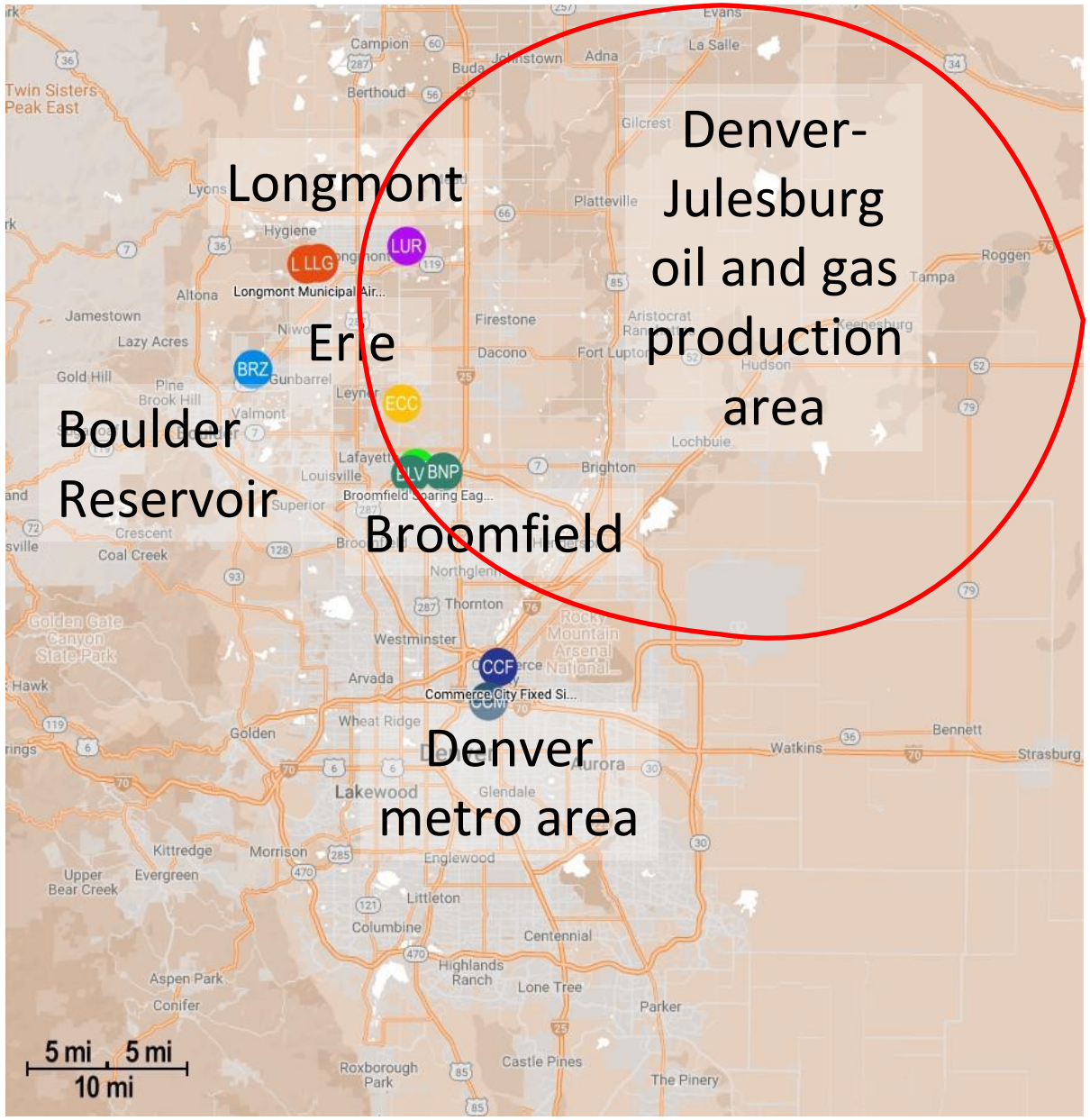


Ozone Design Value trends (2020-2022) across the United States (EPA, 2023)



Methane

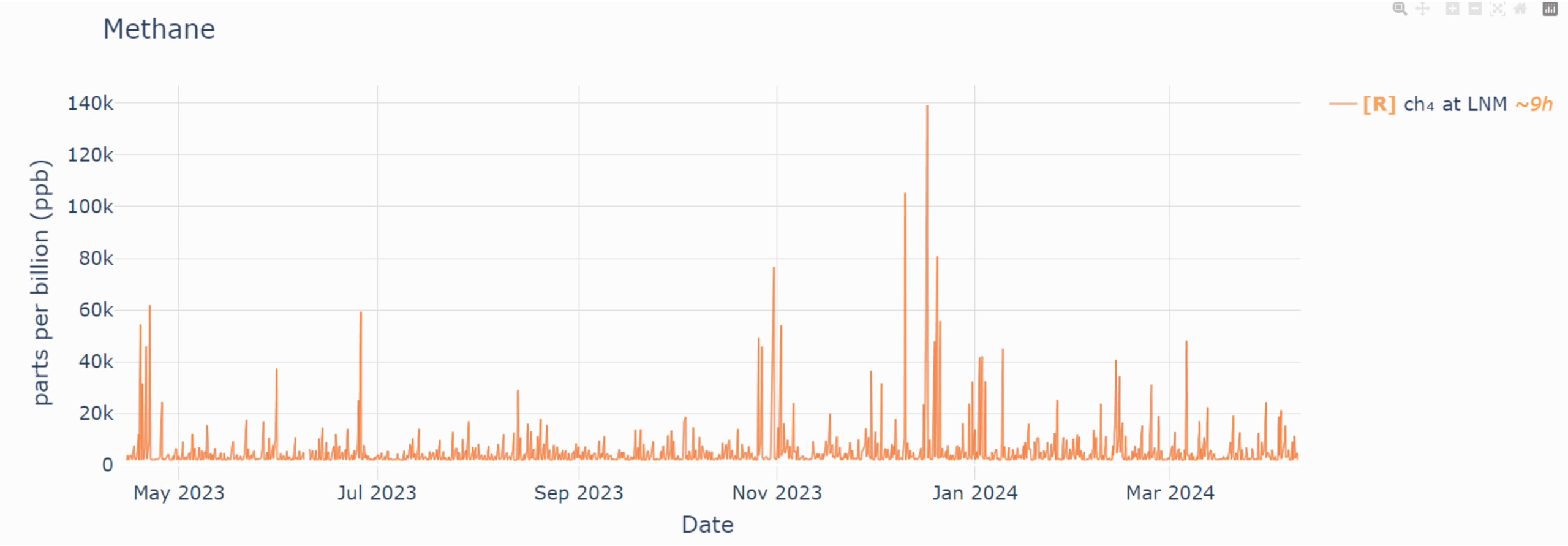
Colorado Front Range Comparison Sites



LUR: Longmont Union Reservoir
LLG: Longmont Lykins Gulch
BRZ: Boulder Reservoir
ECC: Erie Community Center
BNP: Broomfield North Pecos

https://bouldairtools.com/interactive/

Methane at Loving, NM, compared to CO sites



Methane is a potent GHG, contributing one third to global warming from all well-mixed GHG emissions.
Its dominant emissions in SE NM are from the oil and gas industry, manifesting in high concentration plumes.

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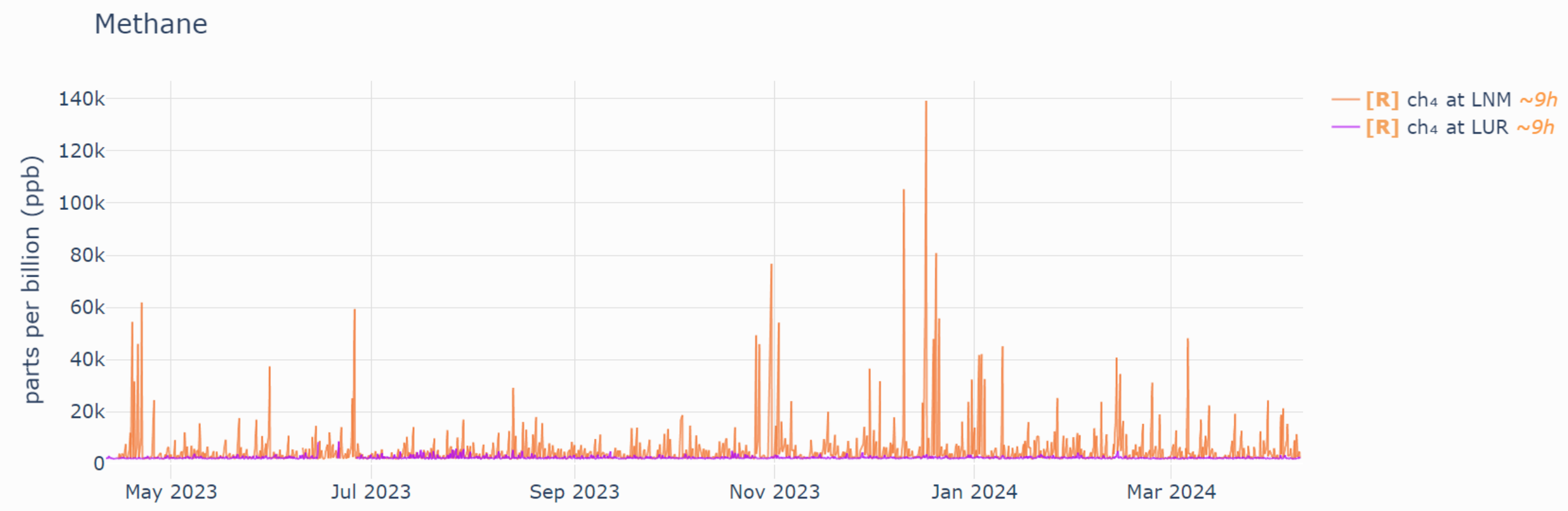

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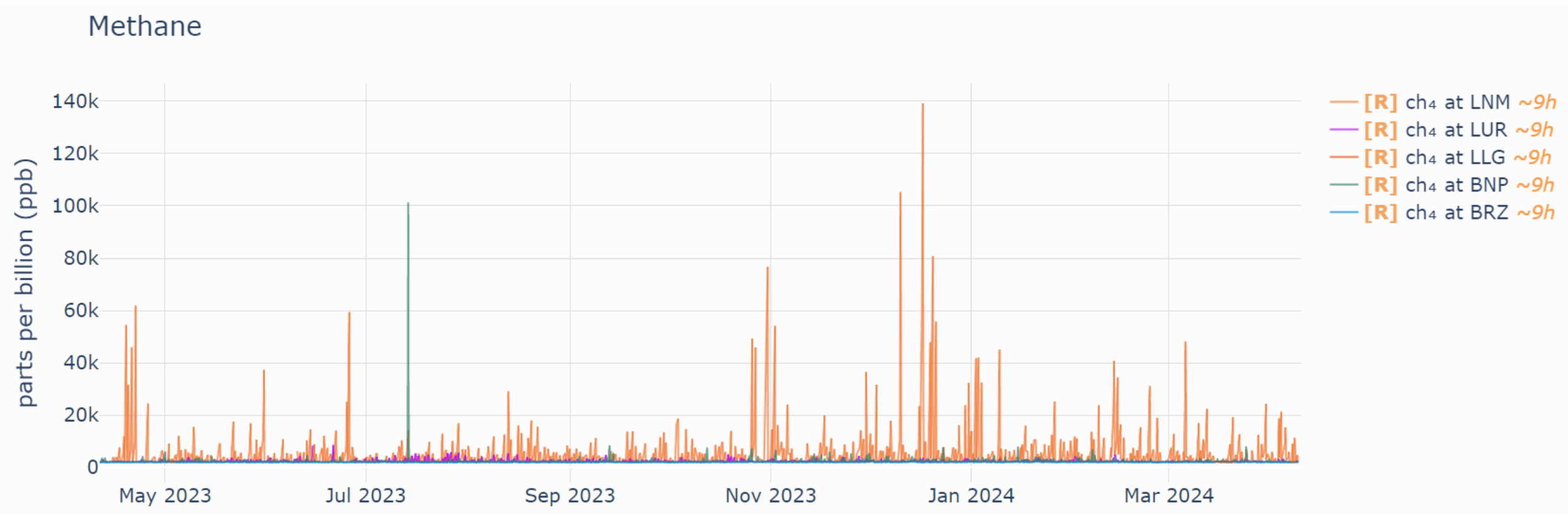
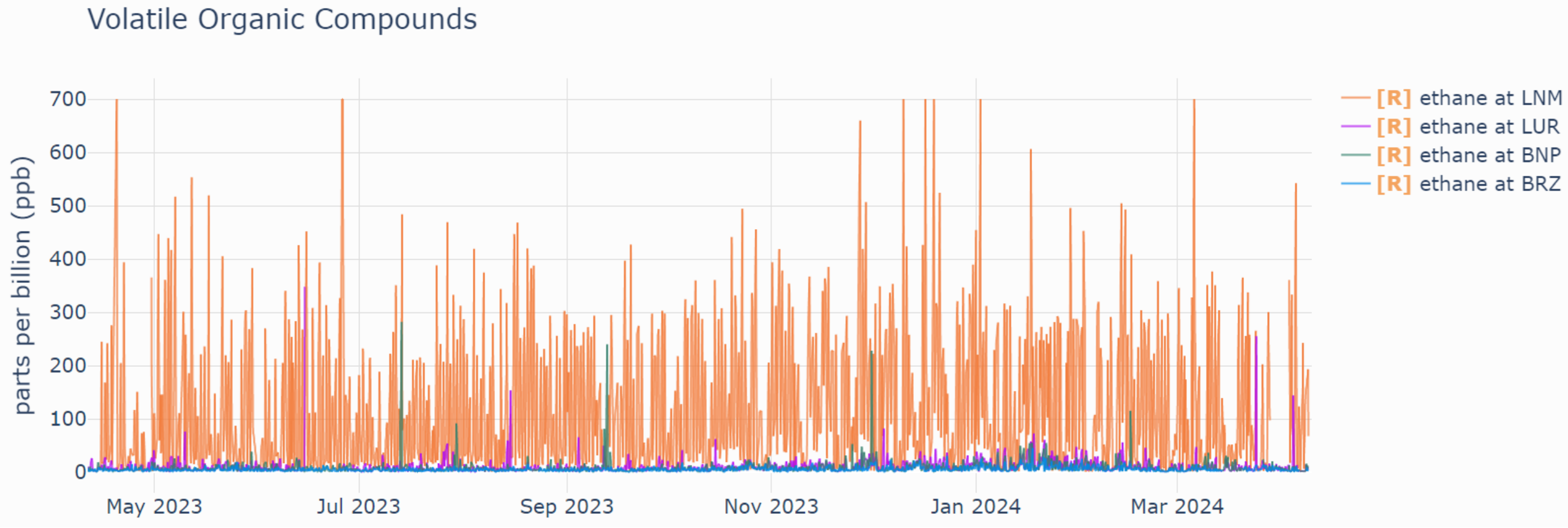


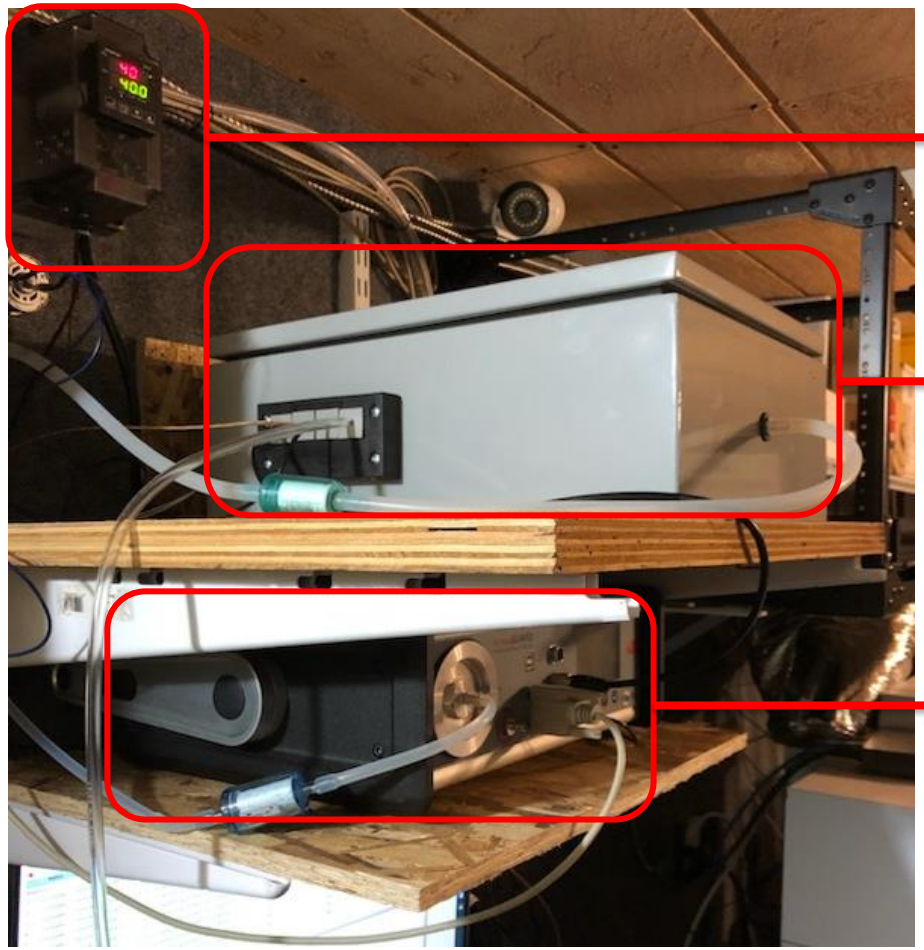
Ethane at Loving, NM, compared to CO sites



The very high similarity between ethane and methane variations and abundances in SE NM confirms their origins in oil and gas industry activity emissions.

Airborne Radioactivity

The radioactivity monitors (inside the trailer):

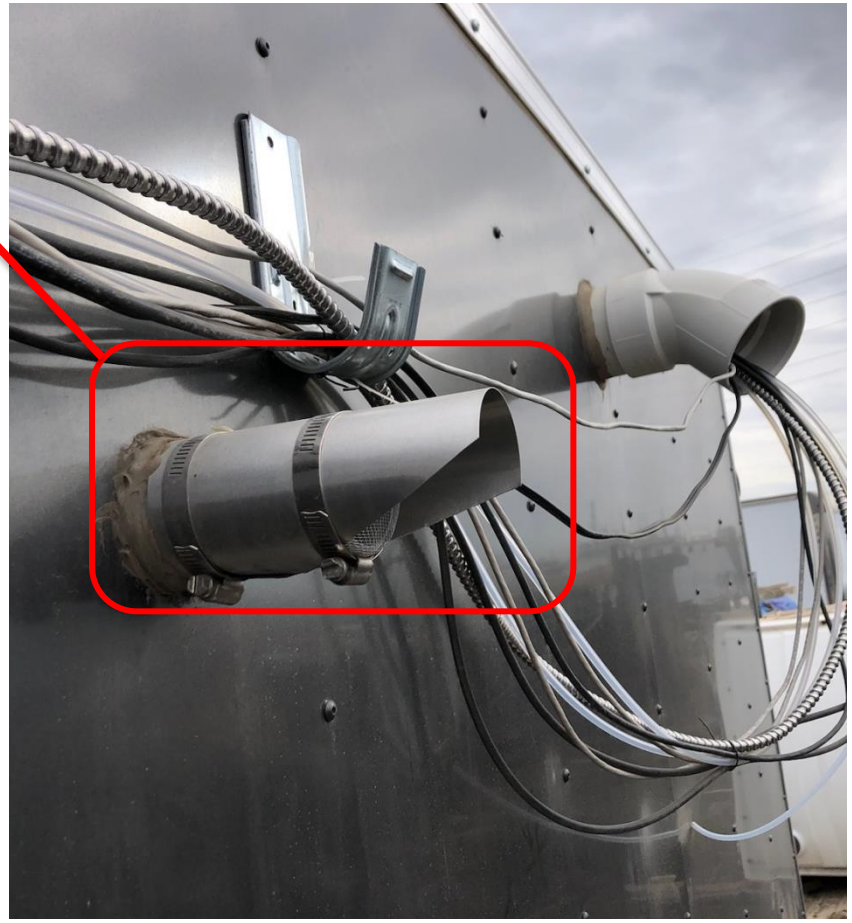


Particle radioactivity monitor inlet temperature controller

Particle radioactivity monitor enclosure

Gas phase radon monitor

Particle radioactivity monitor inlet



Bertin Technologies AlphaGUARD DF2000 + AlphaPM

AlphaGUARD DF2000 Radon gas alpha decay

Detector: Ionization chamber
Range: <0.05 pCi/L to 54,000 pCi/L (2 to 2,000,000 Bq/m^3)
Flow rate 0.05 – 0.5, 1, 2 L/min; 620 mL chamber volume
1 min or **10 min** measurement cycle
5-year calibration factor, traceable

AlphaPM Radon progeny on PM alpha decay

Detector: Semiconductor (PIPS)
Range: 0.5 to 1,000,000 Bq/m^3 EEC (0.02 to 35,000 MeV/cm^3)
Lower detection limit at 10 min and 2 L/min flow: 2 Bq/m^3 EEC (0.07 MeV/cm^3)
Flow rate 0.1, 0.5, 1.0, 1.5, 2.0 L/min
10 min measurement cycle, synchronized automatically with connected AlphaGUARD

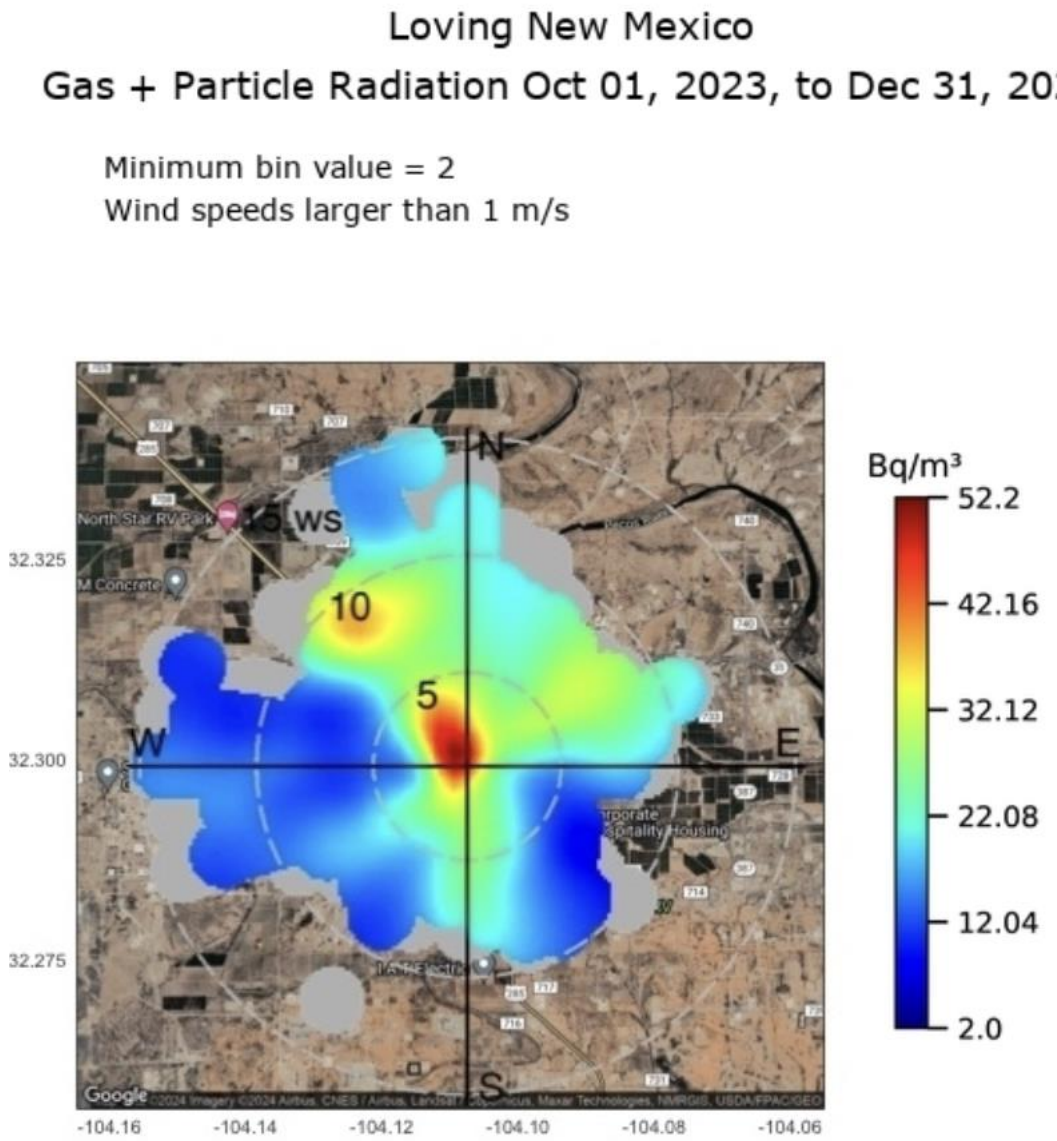
Units for Ambient Radioactivity Monitoring

- Pico-Curie per Liter : pCi L^{-1}
- **Becquerel per cubic meter: Bq m^{-3}**

1 pCi L^{-1} is equivalent to 37 Bq m^{-3}

- Continental background, outdoor air: **5-15 Bq/m^3** (0.135-0.405 pCi/L)
- World Health Organization action level for indoor air: **100 Bq/m^3** (2.7 pCi/L)
- US EPA action level for indoor air: 4 pCi/L (~**150 Bq/m^3**)

New insights from airborne radioactivity measurements

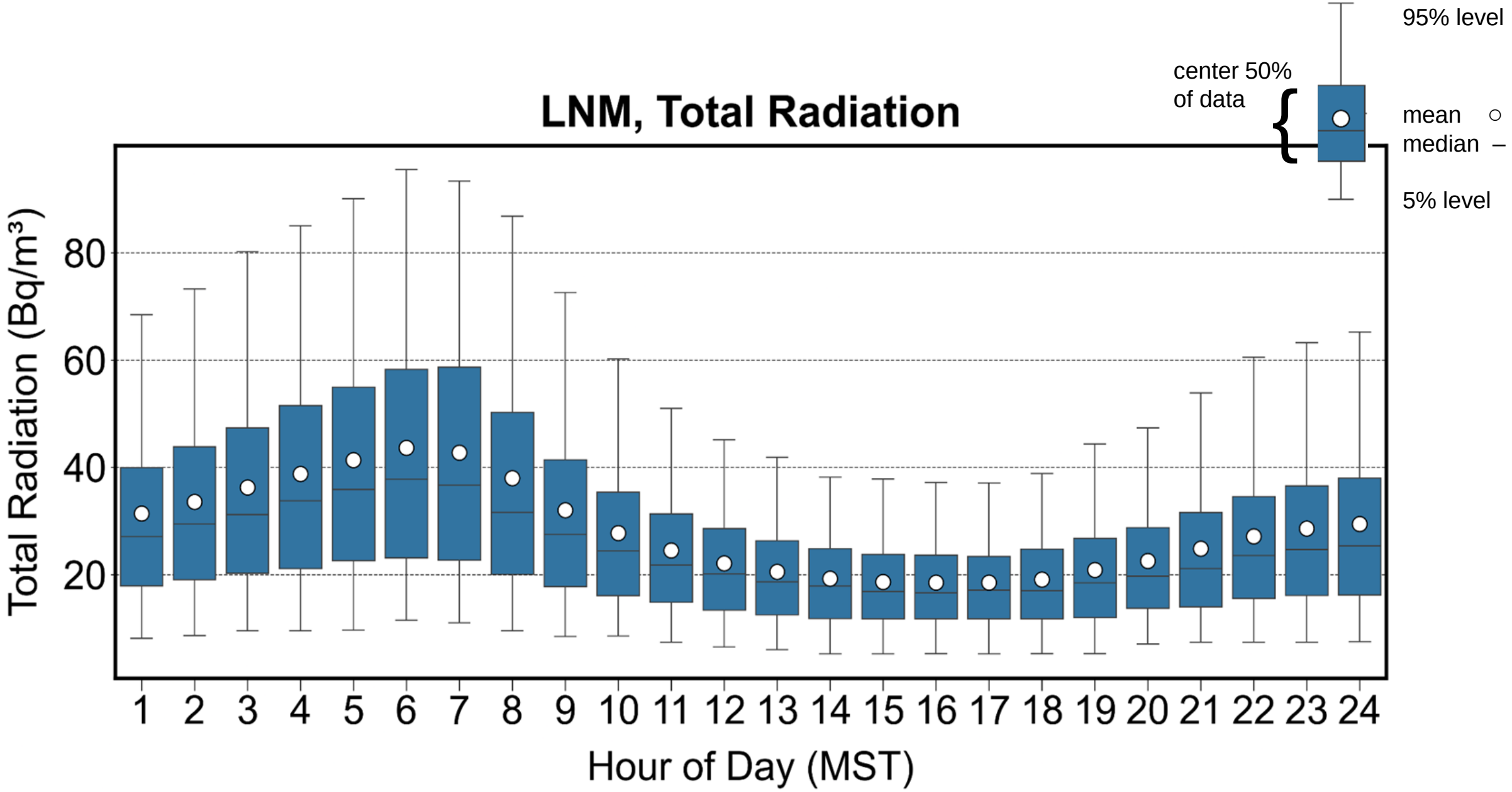


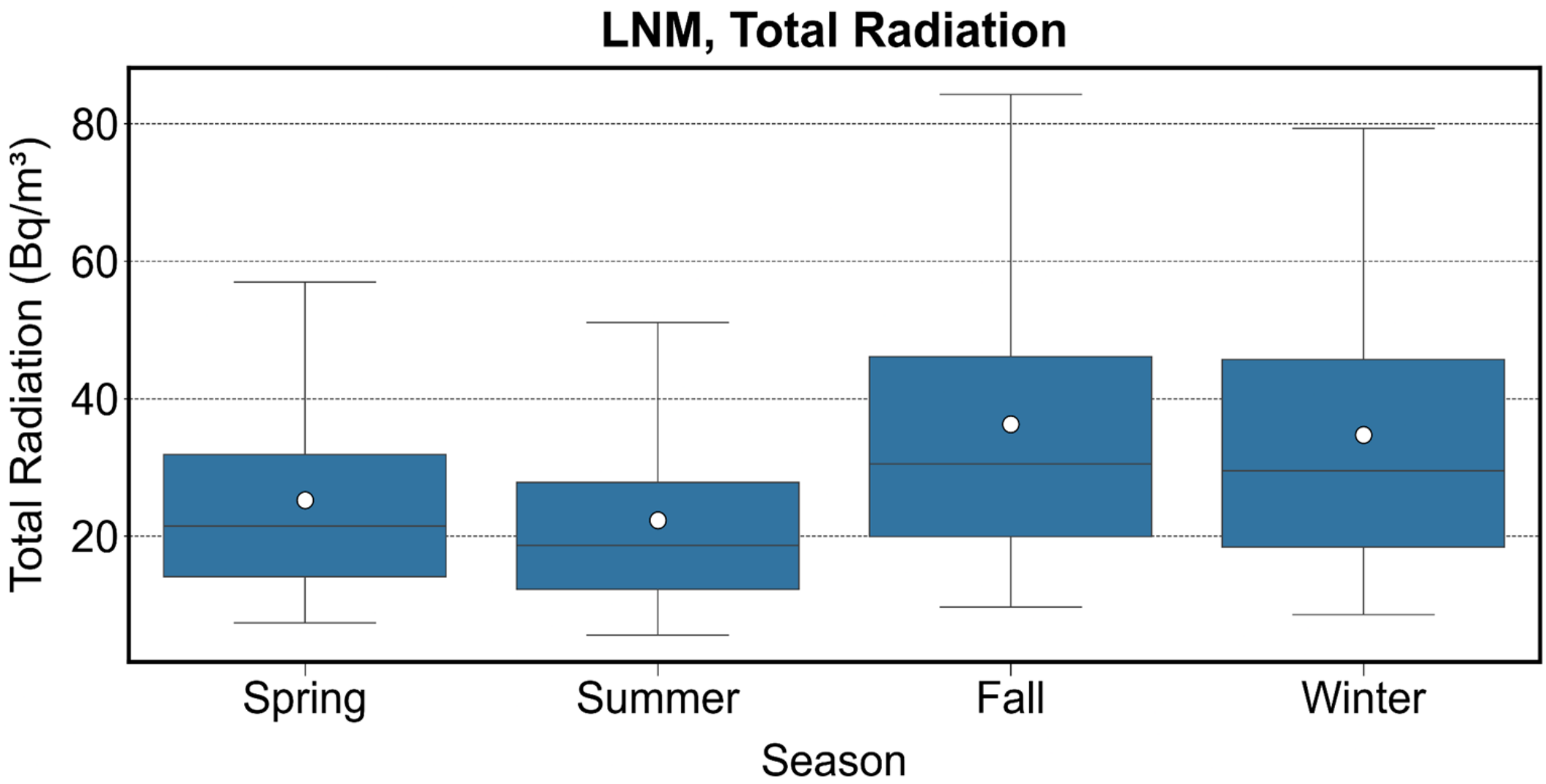
Radioactive <u>Radon is a gas</u> and <u>Radon decay products are on particles</u>

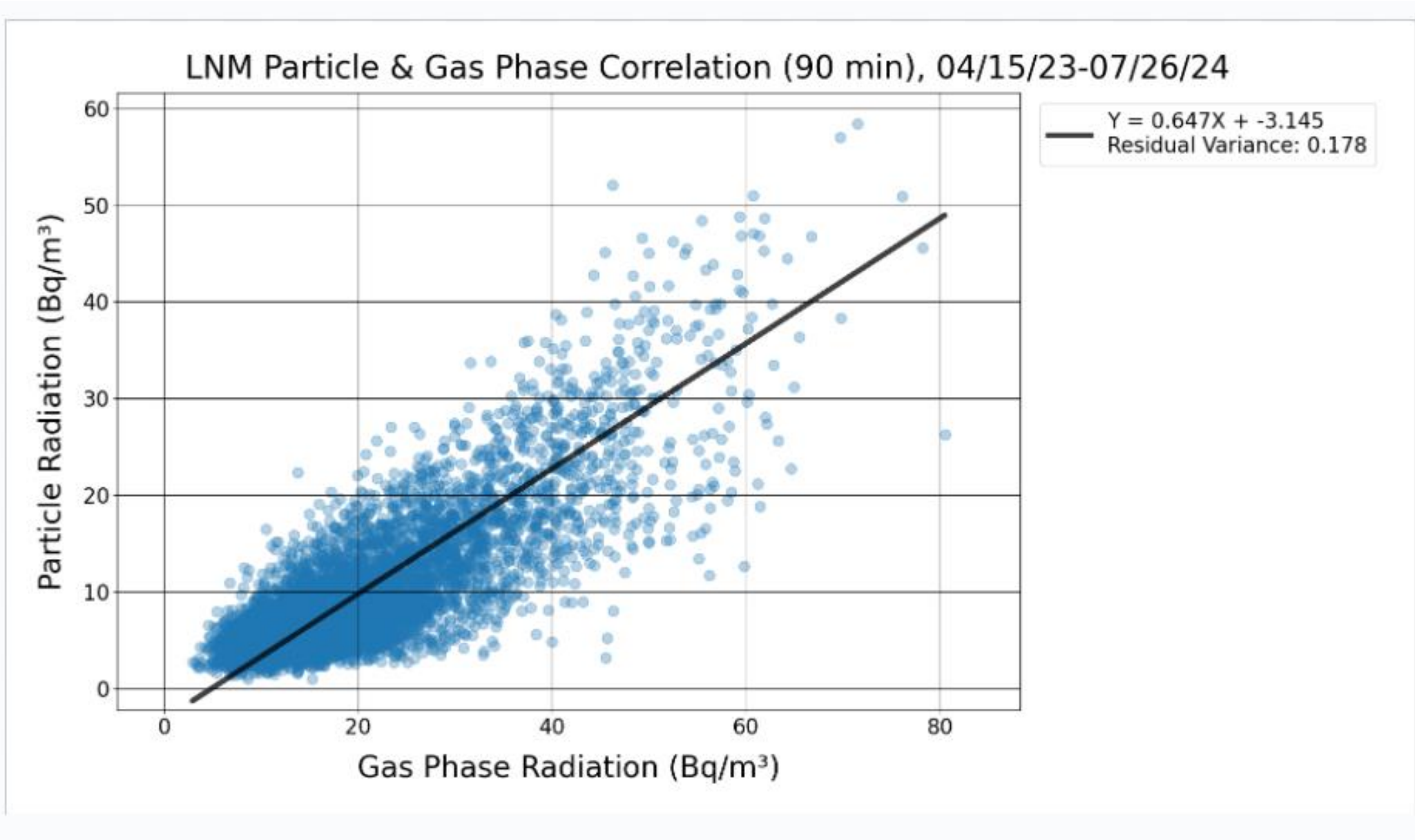
Radon emanation is enhanced as it is brought to the surface via drilling and gas production

- Elevated levels (yellow to red colors) are detected from various directions, especially under moderate northerly, especially NNW wind directions.
  - Under these conditions, levels are on average 2-3 times higher than background* levels (cyan and blue colors).
- Correlation with sulfur compounds may suggest a shared “sour gas” source.

* cf. Gäggeler, *Radiochimica Acta* 70/71, 1995


LNM, Total Radiation
Total Radiation (Bq/m³)
20
40
60
80
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day (MST)
95% level
center 50%
of data
mean ○
median –
5% level


LNM, Total Radiation
Total Radiation (Bq/m³)
80
60
40
20
Spring
Summer
Fall
Winter
Season

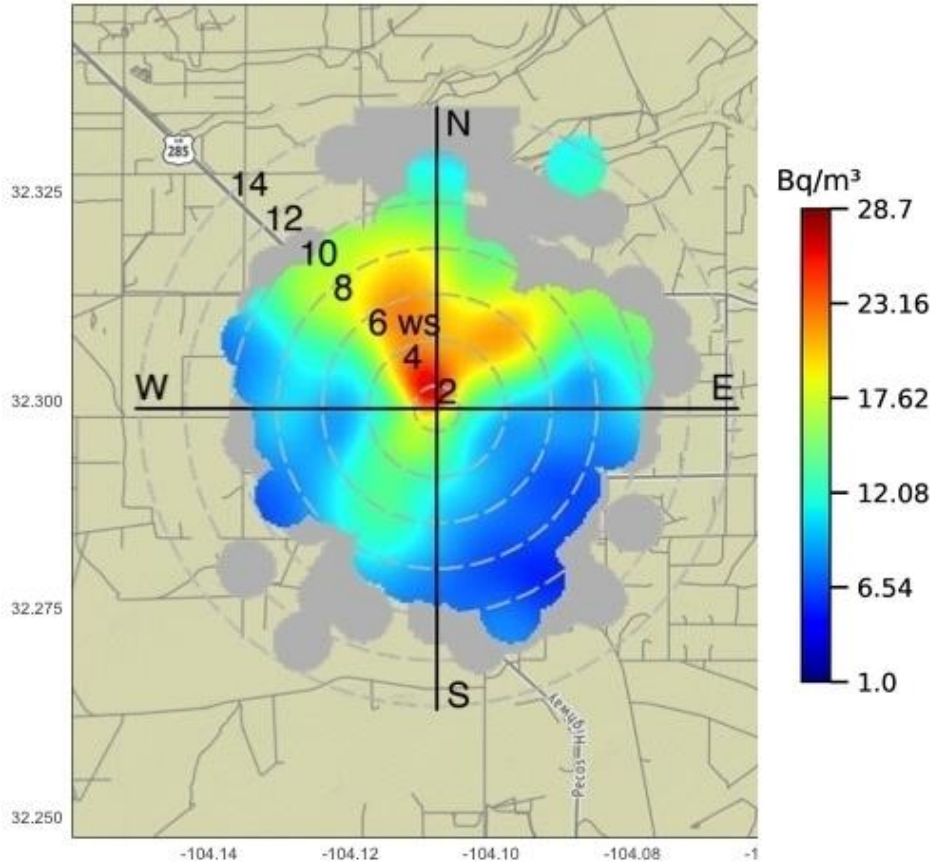

LNM Particle & Gas Phase Correlation (90 min), 04/15/23-07/26/24
Y = 0.647X + -3.145
Residual Variance: 0.178
Particle Radiation (Bq/m³)
Gas Phase Radiation (Bq/m³)
0
10
20
30
40
50
60
0
20
40
60
80

Airborne Radioactivity at Loving, NM (LNM)

Loving New Mexico

Gas Phase Radiation Jul 01, 2023, to Sep 12, 2023

Minimum bin value = 2
Wind speeds larger than 1 m/s



Loving New Mexico

Particle Radiation Jul 01, 2023, to Sep 12, 2023

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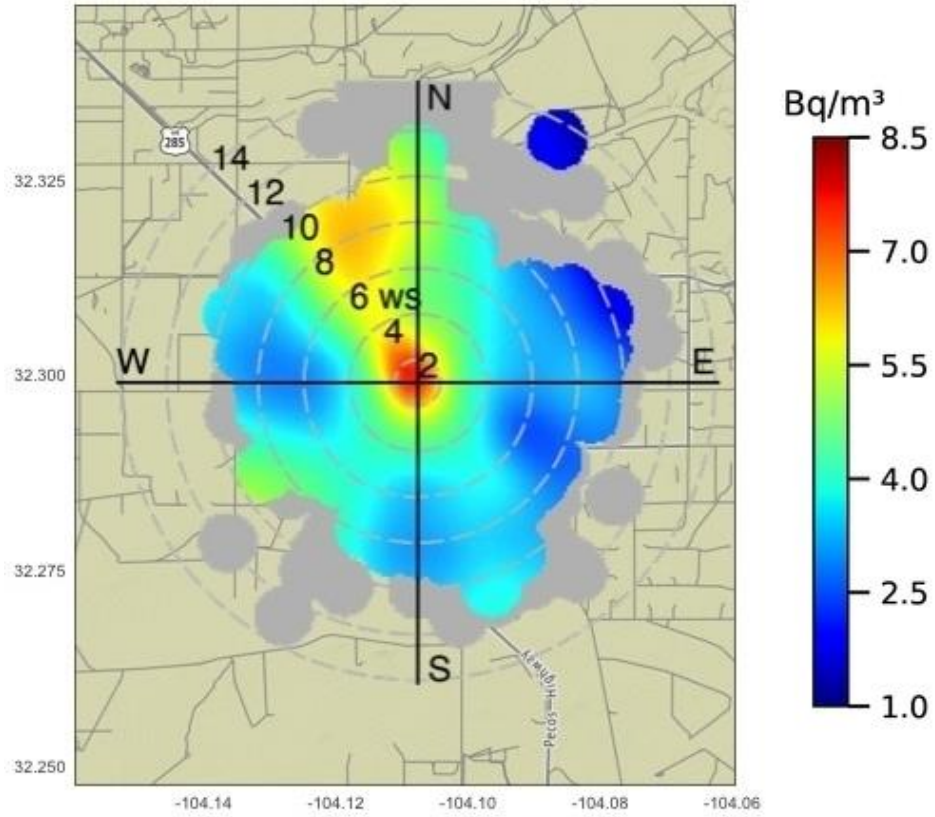
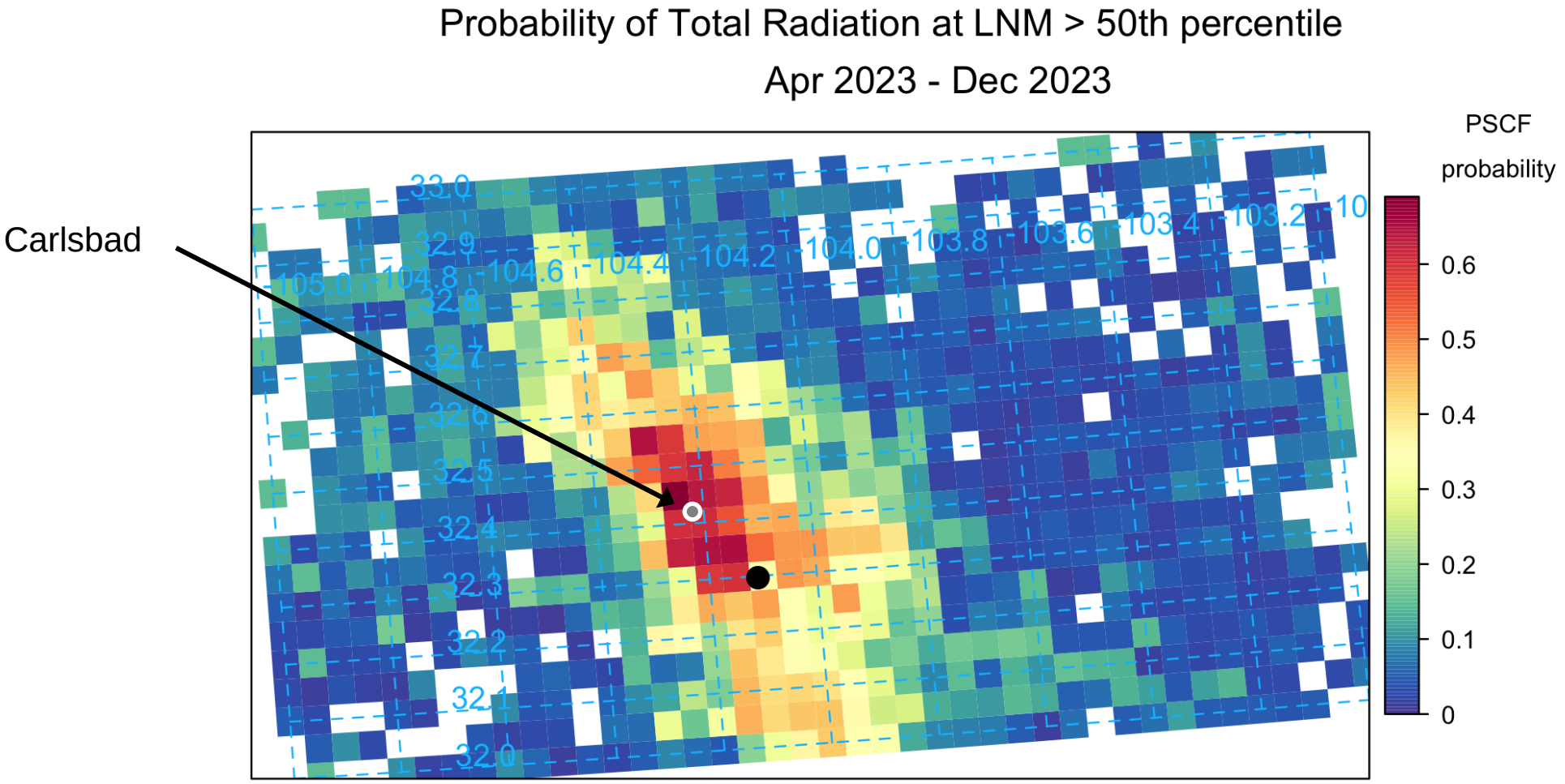
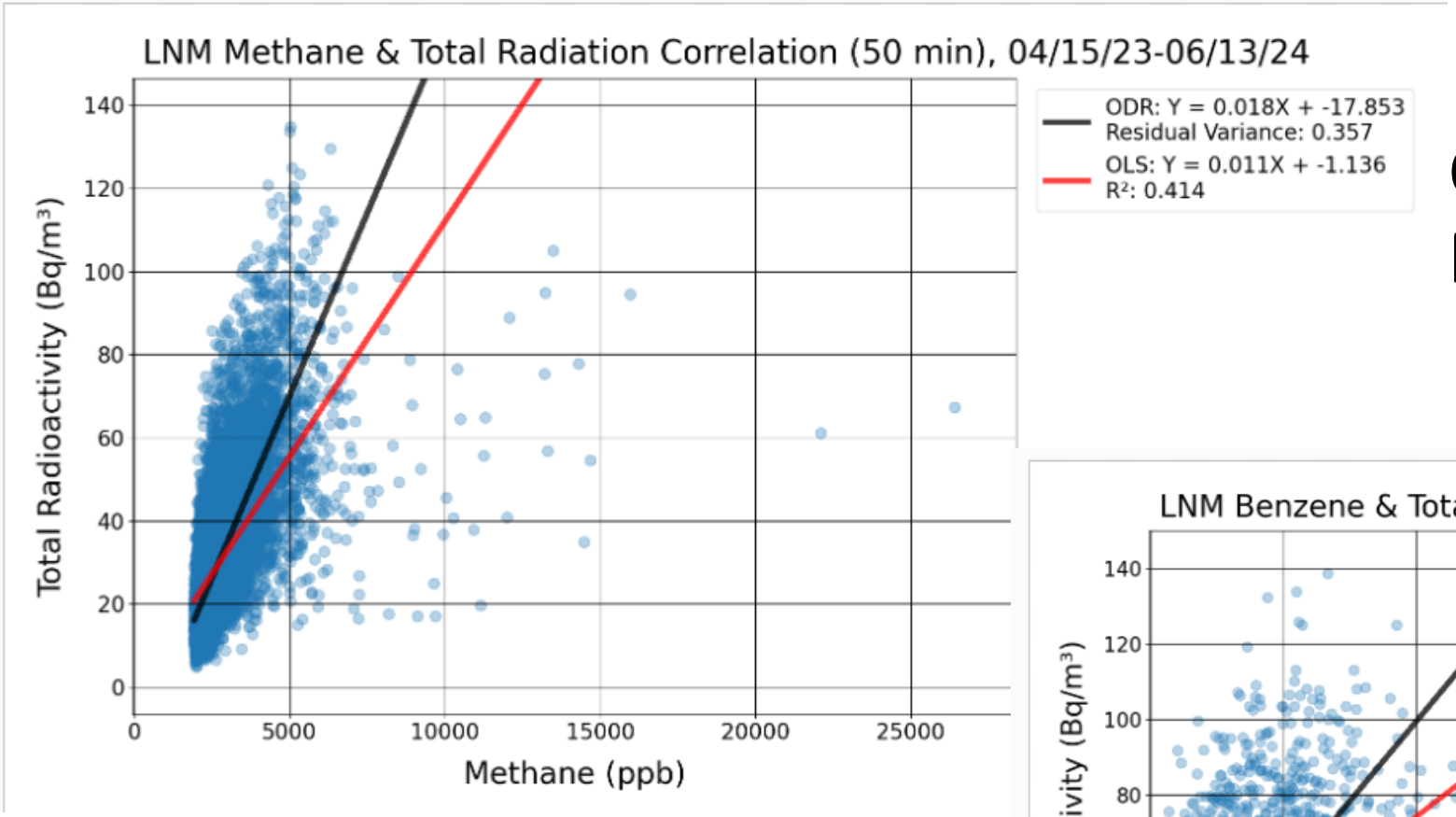
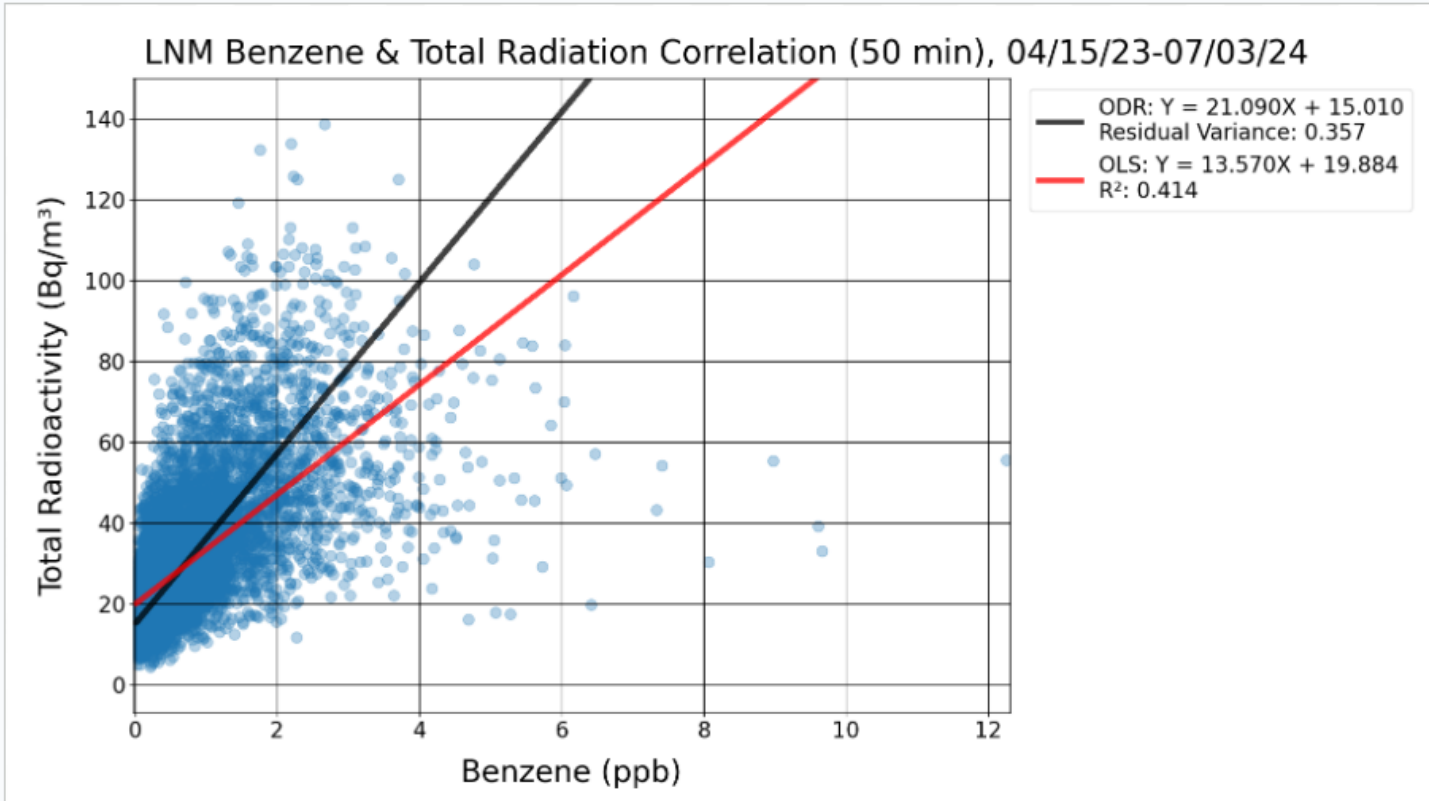


Potential Source Contribution Function Results – Uses Correlation Analyses with HYSPLIT Trajectories



Covariation with Methane and Benzene





Conclusions

- Implemented air monitoring in Loving, NM, in April 2023.
  - Operated continuously with less than 2% downtime since.
- Eddy County has been exceeding the NAAQS threshold since 2018 but has not yet been designated as out of compliance under the Clean Air Act
  - ➢ more 2023 ozone exceedances than comparison sites in CO also affected by oil & gas emissions and in counties in *serious* non-attainment status for the ozone NAAQS
  - ➢ Comparing our data with other monitoring results suggests that ozone pollution levels are increasing, defying trends seen in most of the USA (EPA, 2023).
  - ➢ Our data, and several prior peer-reviewed studies, suggest the regional ozone problem is largely due to NOx and VOC emissions from oil and gas industry operations.
- This study identified enhanced local Radon emissions that result in elevated levels of airborne radioactivity.

Assessing source contributions to air quality in southeast New Mexico

Research Team

Meredith Franklin (UToronto, USC)
Exposure assessment, statistics, data science

Gunnar Schade (TAMU)
unconventional oil and gas development measurement, distributed sampling

Detlev Helmig (Boulder A.I.R.)
unconventional oil and gas development measurement, fixed station monitoring

Jill Johnston (USC)
Environmental health and justice, community engagement

Lara Cushing (UCLA)
Environmental health and epidemiology, community engagement

Acknowledgements

- Funding
  - Disclaimer: none of the research results presented herein have yet undergone HEI's rigorous peer review process

- We are grateful to ConocoPhillips for letting us carry out this research on their property in Loving, NM