October 7, 2020, ozone maxima:

Boulder Reservoir: 82.1 ppb
Longmont Airport: 80.5 ppb
Longmont Union Reservoir: 73.7 ppb
Broomfield Soaring Eagle: 82.9 ppb
Air Quality Monitoring at the Boulder Reservoir

Detlev Helmig

• Review of the Monitoring Program
• What’s New?
• Remarkable 2020:
  - Ozone
  - COVID
  - Fires
• Concentration Changes (Trends)

Note: All 2020 data and analyses in this presentation are preliminary!
Please direct any questions to dh.bouldair@gmail.com
Air Quality Impacts of Oil and Gas Development (Fracking, Wells, Storage, Distribution, Pipelines, Flaring, ......)

- Fracking Fluid
- Silica
- Diesel Exhaust
- **Nitrogen Oxides**
- Dust
- Particulate Matter
- **Fugitive Emissions of Oil and Gas**
  - Methane
  - Volatile Organic Compounds
  - Polycyclic Aromatic Hydrocarbons
- **Hydrogen Sulfide, H₂S**
O&NG Emissions - Methane and Volatile Organic Compounds (VOCs)

- Ethane ($\text{C}_2\text{H}_6$)
- Propane ($\text{C}_3\text{H}_8$)
- n-Butane ($\text{C}_4\text{H}_{10}$)
- iso-Butane ($\text{C}_4\text{H}_{10}$)
- n-Pentane ($\text{C}_5\text{H}_{12}$)
- iso-Pentane ($\text{C}_5\text{H}_{12}$)
- Methane ($\text{CH}_4$)
- Benzene ($\text{C}_6\text{H}_6$)
- Toluene ($\text{C}_7\text{H}_8$)
- Xylenes ($\text{C}_8\text{H}_{10}$)

Natural Gas

Oil
Boulder Reservoir Air Monitoring Shelter (CDPHE)
Real Time Monitoring and Real Time Reporting of Air Quality and Oil and Gas Emissions
* Fully automated
* 24/7, 365 days per year
* Sensitivity well sufficient to capture full range of atmospheric concentrations
* Regulatory/research-grade instrumentation (NASA, NSF, NOAA, EPA, CDPHE)
* Calibrations referenced to EPA, CDPHE, NOAA, Global Atmospheric Watch
* Working with CDPHE and EPA on audits, quality control
* Peer-review research quality
* Legally defensible
What’s New?
New Website, New URL
https://www.bouldair.com/boulder
Two Partner Websites

Website Visits since May 24, 2020
(~ 30-50 per day each per site)

2684

6370

3647
New Website with direct comparison of monitoring data within network in real time:

https://www.bouldair.com/NoCoFrontRange.htm
Interactive Data Analysis Tool

Boulder A.I.R.
Interactive Data Analysis Tool

Site Selection
- Many sites mode
- One site mode

Data Selection
- CH4
- O3
- VOCs
- NOx
- PM

Data Window
- Dates: 04/01/2020 → 09/07/2020
- Graph height

Volatile Organic Compounds

"DISCLAIMER": All numerical and graphical data displayed at this portal are preliminary. Boulder A.I.R. does not bear any responsibility for the correctness of the data and any interpretations or conclusions that may be drawn from the data.
Automated E-Mails with Air Quality Alerts (Sept. 6-7)

Current Air Quality Alert Thresholds for Broomfield:

Ozone > 70.9 ppb
Benzene > 0.9 ppb
PM2.5 > 35 μg m⁻³
Remarkable Year 2020 !
News Releases from Region 08

EPA reclassifies Denver area to “Serious” nonattainment for ozone

Reclassification requires additional control measures to reduce emissions

12/16/2019

Contact Information:
Richard Mylott (mylott.richard@epa.gov)
303-312-6654

DENVER—The U.S. Environmental Protection Agency (EPA) today announced the agency is finalizing a determination to reclassify the Denver Metro/North Front Range ozone nonattainment area from Moderate to Serious nonattainment under the Clean Air Act.
Elevated Levels of Surface Ozone can cause:

- Shortness of breath
- Chest pain when inhaling deeply
- Wheezing and coughing
- Increased susceptibility to respiratory infections
- Inflammation of the lungs and airways
- Increased risk of asthma attacks

\[\text{\textbullet\quad} \text{(American Lung Association)}\]

\[\rightarrow \text{Increased risk of death;}\]
\[\sim 5000-6000 \text{ premature deaths in US per year}\]
BRZ Ozone
(Note: All BRZ Ozone Data are from CDPHE)
Summer 2020 Ozone
(Note: All Data are Preliminary)

Ozone National Ambient Air Quality Standard (mean 8-hours > 70 ppb)

BRZ – Boulder Reservoir
LMA – Longmont Municipal Airport
LUR – Longmont Union Reservoir
BSE – Broomfield Soaring Eagle
2020:
60-65 Days with Ozone above 70 ppb
~18 Days with 8-hour averaged Ozone above 70 ppb

BRZ – Boulder Reservoir
LMA – Longmont Municipal Airport
LUR – Longmont Union Reservoir
BSE – Broomfield Soaring Eagle

Ozone National Ambient Air Quality Standard (mean 8 hours > 70 ppb)
Ozone
July 10 Event

The graph shows the ozone levels over a period from July 9 to July 11, 2020. The data is represented for three locations: BRZ, LMA, and LUR. The x-axis represents the time of day, and the y-axis represents parts per billion (ppb) of ozone. The graph illustrates fluctuations in ozone levels throughout the day at each location.
Ozone National Ambient Air Quality Standard

Ozone

July 10 Event
**Ozone**

- air flow from north to northeast

**Wind Speed**

**Wind Direction**

- air flow from northeast
- air flow from west to southwest
Where is the High Ozone Coming From?
BRZ, 2017-2020, daytime, June-August, winds > 1 m/s
Ozone by Wind Direction/Speed Summer 2020

Front Range Air Monitoring Network
Ozone Summary

- 2020 was a relatively high ozone year
- 1\textsuperscript{st} ozone exceedance was already observed on April 17
- Latest ozone exceedance observed yesterday (October 7) with 82 ppb maximum at BRZ
- Close to 70 days when ozone exceeded 70 ppb
- Maximum value of 118 ppb observed on August 25
- 5 consecutive days with exceedance of the NAAQS in August
- Overall, approx. 18 days when NAAQS was exceeded.
- High ozone occurrences are predominantly associated with easterly transport. Very consistent across network sites.
Emission Changes from COVID ?
Emission Changes from COVID?

Ethane

parts per billion (ppb)

Emission Changes from COVID?

BRZ Ethane by Month and Year

- Ethane (ppb)
- Months: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
- Years: 2017, 2018, 2019, 2020

Graph showing variations in ethane levels by month and year.
Emission Changes from COVID?
Emission Changes from COVID?

BRZ Ethane in April each Year

Median Mean

Linear regression trend line through medians

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<td>8.24</td>
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</table>
Emission Changes from COVID?

1. BRZ Ethane in April each Year
   - Y = 0.49 X
   - Emission levels show a slight increase from 2017 to 2020.

2. BRZ Propane in April each Year
   - Y = 0.057 X
   - Emission levels show a slight increase from 2017 to 2020.

3. BRZ Benzene in April each Year
   - Y = -0.087 X
   - Emission levels show a slight decrease from 2017 to 2020.

4. BRZ NOx in April each Year
   - Y = -0.13 X
   - Emission levels show a slight decrease from 2017 to 2020.

5. BRZ Ozone in April each Year
   - Y = -0.215 X
   - Emission levels show a slight decrease from 2017 to 2020.
COVID Summary

• Difficult to evaluate because of large year-to-year variability
• Further complicated by time of year -> strong seasonal changes during spring
• Can not decipher clear signal for most pollutants.
• Remarkably, had one of the earliest ozone exceedance days (April 17) this year.
• Emissions reduction most likely for nitrogen oxides.
Wildfires
Particles in Fire Smoke Events

Particulate Matter

Micrograms per Cubic Meter (µg m⁻³)

- PM2.5 at LUR
- PM2.5 at BSE
EPA 24-hour Health Standard (35 µg m⁻³)
September 17 Smoke Event
Nitrogen Oxides

Particulate Matter
Fire Plumes Summary

- Very clear enhancements in particulate matter PM10 and PM2.5. Up to 100 x background.
- Exceeded EPA health standard for PM2.5 on eight days.
- No clear association between fire plume occurrences and elevated ozone.
- Ozone precursors (VOCs, NOx) do not show clear enhancements in fire plumes above typical regional levels.
- Background of benzene and acetylene is enhanced, but still well below variability and pollution spikes seen from regional non-wildfire pollution sources.
Changes in Concentrations ("Trends")

Ethane at BRZ

BRZ Ethane by Month and Year

BRZ Ethane in August each Year

Ethane Changes
Changes in Concentrations ("Trends")

- Ethane Changes
- Benzene Changes
- Propane Changes
- Acetylene Changes
- N-Butane Changes
- NOx Changes
Comparison of Inventory Oil and Gas VOCs Emission Changes with Observational Data

RAQC/CDPHE/AQCC: Regional Air Quality Council, State Implementation Plan for the 2008 8-Hour Ozone National Ambient Air Quality Standard, 2020
Comparison of Inventory Oil and Gas Emission Changes with Observational Data

**RAQC/CDPHE/AQCC**: Regional Air Quality Council, State Implementation Plan for the 2008 8-Hour Ozone National Ambient Air Quality Standard, 2020

**BAO/NOAA**: Oltmans et al., Atmospheric Oil and Natural Gas Hydrocarbons in SW Weld County, CO, During 2008-2016 Show Little Change Despite Stricter Industry Emissions Regulations, submitted for publication. NE sector samples, year-round medians minus propane background (5th percentile value), scaled to intercept 2011 RAQC value.
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BRZ: All yearly data, minus background (overall 5th percentile value)
Comparison of Inventory Oil and Gas Emission Changes with Observational Data

Inventory projections of emissions reductions have been $5 \times$ higher than what the data show.
Comparison Inventory NOx All Sources Changes versus BRZ observations

RAQC/CDPHE/AQCC: Regional Air Quality Council, State Implementation Plan for the 2008 8-Hour Ozone National Ambient Air Quality Standard, 2020

BRZ: All data, median of seven monthly regression results.
Where Do the VOCs originate?

Ethane at BRZ <-> Niwot Ridge

Niwot Ridge

Boulder Reservoir

Niwot Ridge Data from NOAA GMD Network
Ethane at BRZ compared to Longmont and Broomfield sites
Dependency of Selected Gases on Winds
Presentation Summary

• 3.5 years of air quality monitoring at BRZ.
• Site has become a flagship of a now 5-station network.
• Continuous data, >95% data coverage.
• Results are reported in near real-time to website portal.
• Several new partner and merged data websites added.
• Data have become a resource to evaluate horizontal concentration gradients within the county and beyond, pollution events and emission changes, trends in pollutants, inventories, ......