

# Air Pollutants & Monitoring



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# Front Range Air Quality Concerns

- VOCs / Hazardous Air Pollutants
  - Vehicles
  - Oil and gas
  - Power plants
- Particulates / Wildfire Smoke
- Ozone / Smog
  - Vehicles
  - Oil and gas
  - Household activities – painting, fueling, mowing

# Health Impacts of VOCs

**Health Effects**

VOC exposure in indoor environments can:

- Irritate the eyes, nose, and throat
- Cause headaches and dizziness
- Potentially lead to visual impairment or memory loss

VOCs also contribute to a number of adverse environmental problems, especially in urban areas.

**Environmental Effects**

**Acid Rain**

- Acid rain pH level: 4.2 - 4.4
- Normal rain pH level: ~5.6

Acid rain can kill aquatic wildlife, wash away vital nutrients from soil, and release aluminum, which harms trees and animals.

**Ozone**

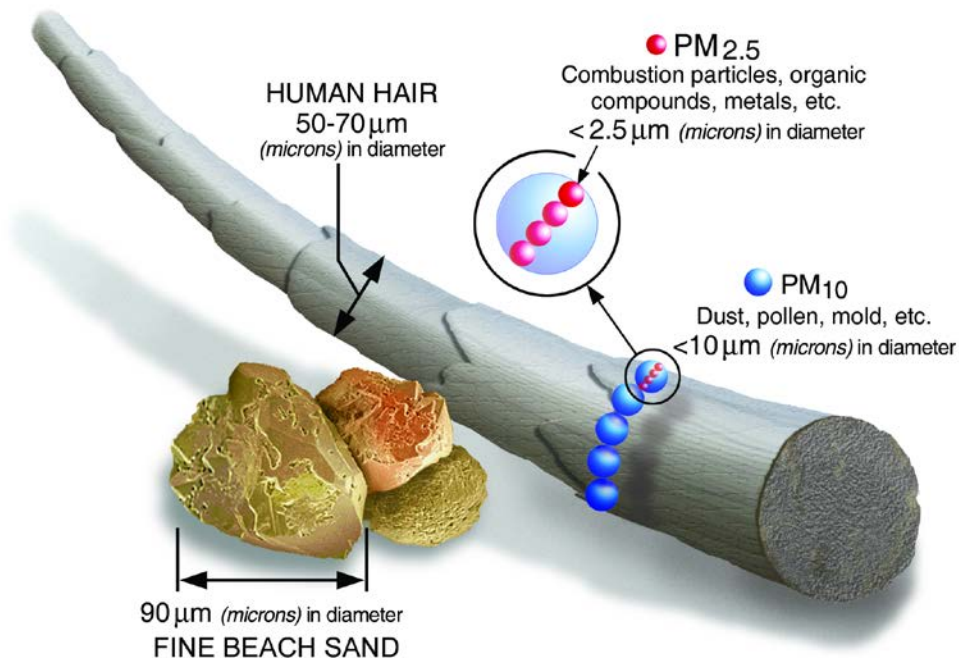
VOCs & nitrogen oxides combine & react with sunlight, ozone forms at the ground-level, leading to smog.

Ground-level ozone formation can cause plants to develop diseases, reduces growth, & leaves them unable to fight off pests & stress.

- VOCs can irritate the eyes, nose and throat
- Cause difficulty breathing and nausea
- Damage the central nervous system and other organs
- Some VOCs can cause cancer

# Particulate Matter

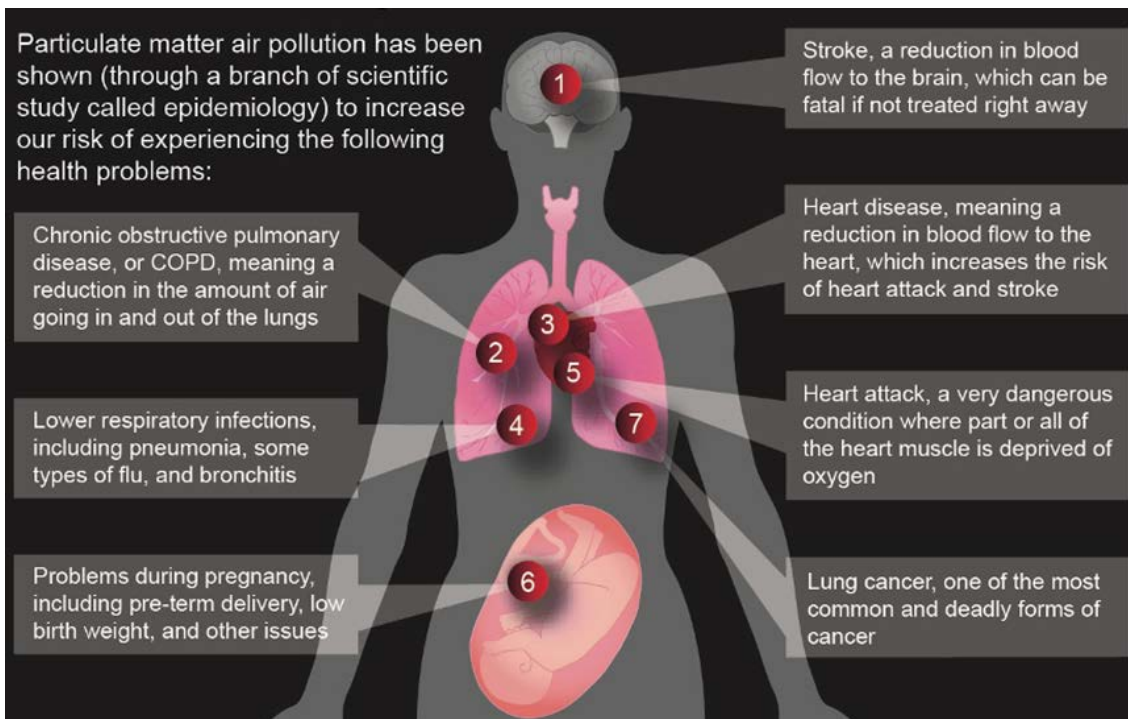
PM<sub>2.5</sub> particles are so small that they can travel deep into the lungs and enter the bloodstream



Graphic Source: EPA

# Health Impacts of Particulate Matter

Once inside the body PM can harm all major organs



Graphic Source: NASA

# Wildfires

## Pollutants

- Particulate matter is the primary pollutant
- Carbon monoxide
- Air toxins – such as benzene and formaldehyde

## Health effects

- Eye and respiratory irritation
- Reduced lung function and bronchitis
- Asthma exacerbation
- Premature death

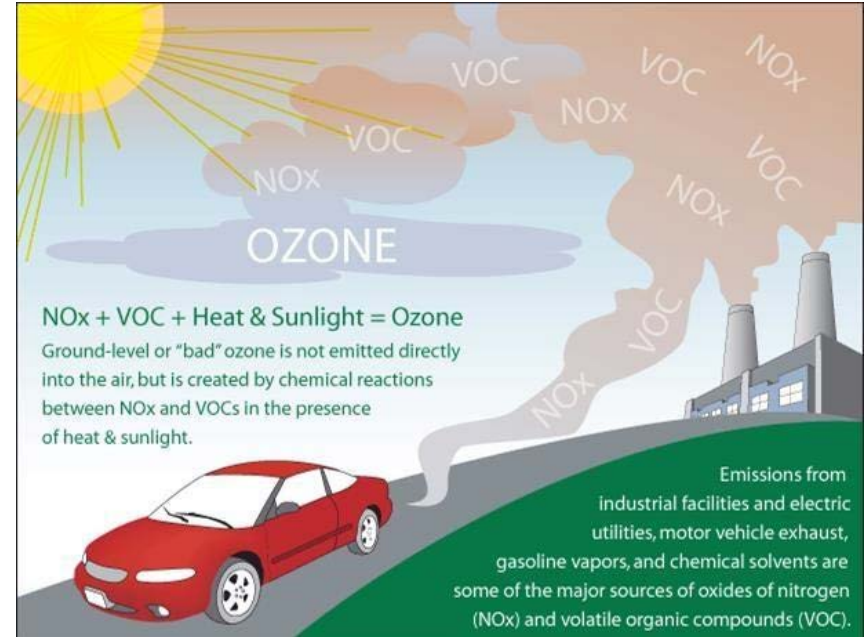
## Sensitive Populations

- Children, elderly, asthmatics, COPD



# Ground-level Ozone

- Ozone – good up high, bad nearby
- Triggers a variety of health problems
- Denver Metro/North Front Range ozone nonattainment area
- Oil & gas and vehicles are largest contributors in the Front Range

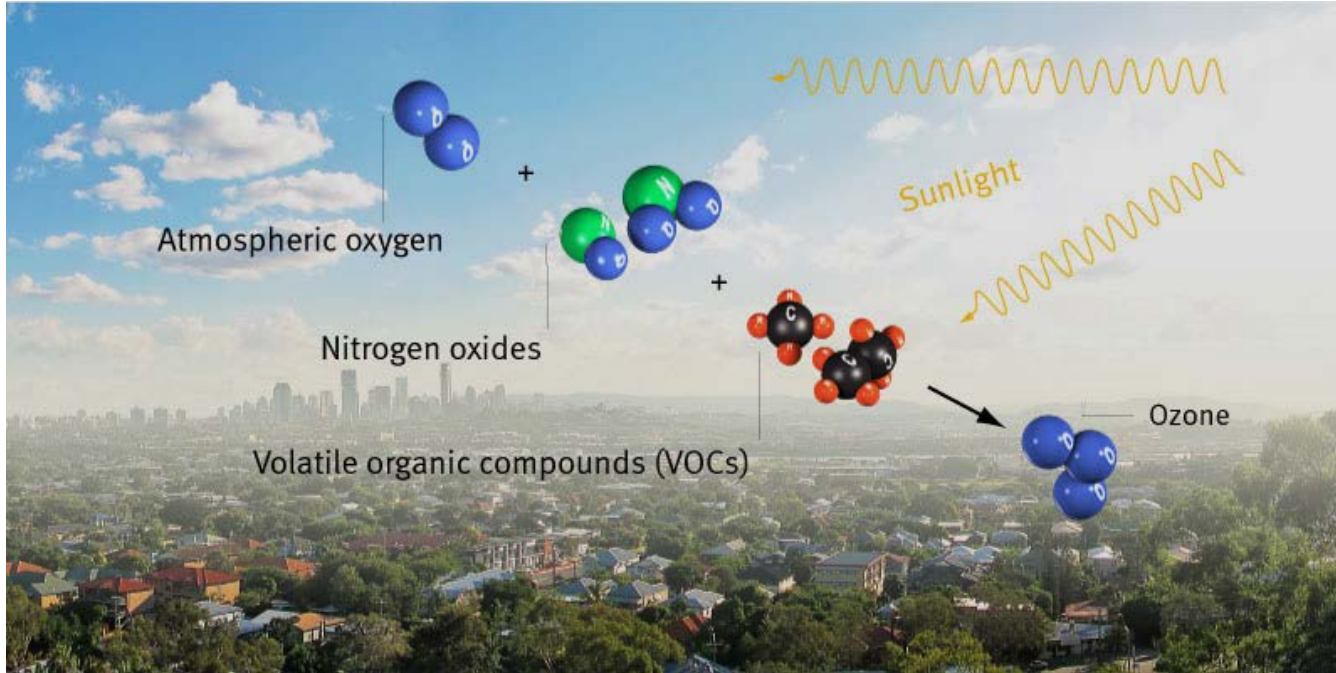


Source: EPA



# Ozone Isn't Emitted

How is ozone formed?





# Ozone: Health and Climate Impacts

- Breathing ground-level ozone causes short- and long-term symptoms such as:
  - Coughing, tightness or discomfort in the chest, and wheezing or shortness of breath.
  - Severe asthma attacks, increased hospitalizations, and increased illness and death rates
- Ozone particularly impacts minority and low-income populations
- Ozone is a greenhouse gas which worsens climate change and climate change worsens ozone pollution
  - Cyclical reinforcement hastens ozone pollution and the climate crisis

# Ozone Doesn't Just Harm Humans

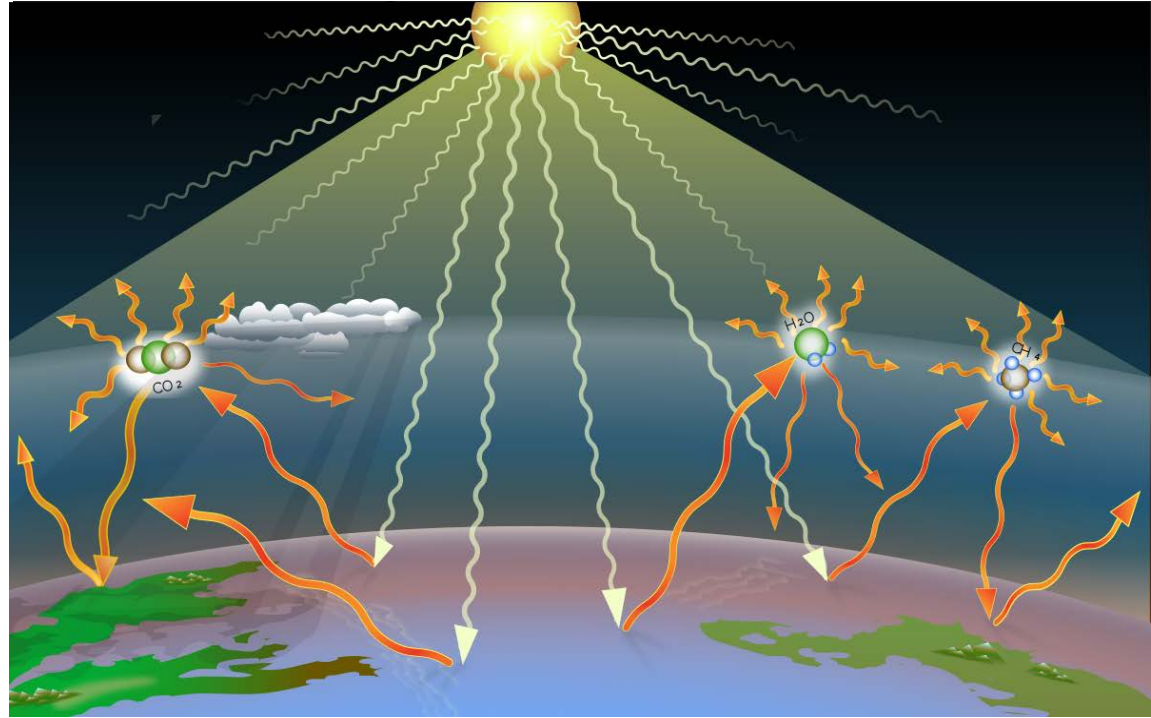
**Ozone can  
increase forest  
susceptibility to  
drought and pest  
attacks**



*Graphic Source: USDA*


# Ozone and Climate Change

Ozone is a greenhouse gas which worsens climate change and climate change worsens ozone pollution



Graphic Source: Wikimedia Commons

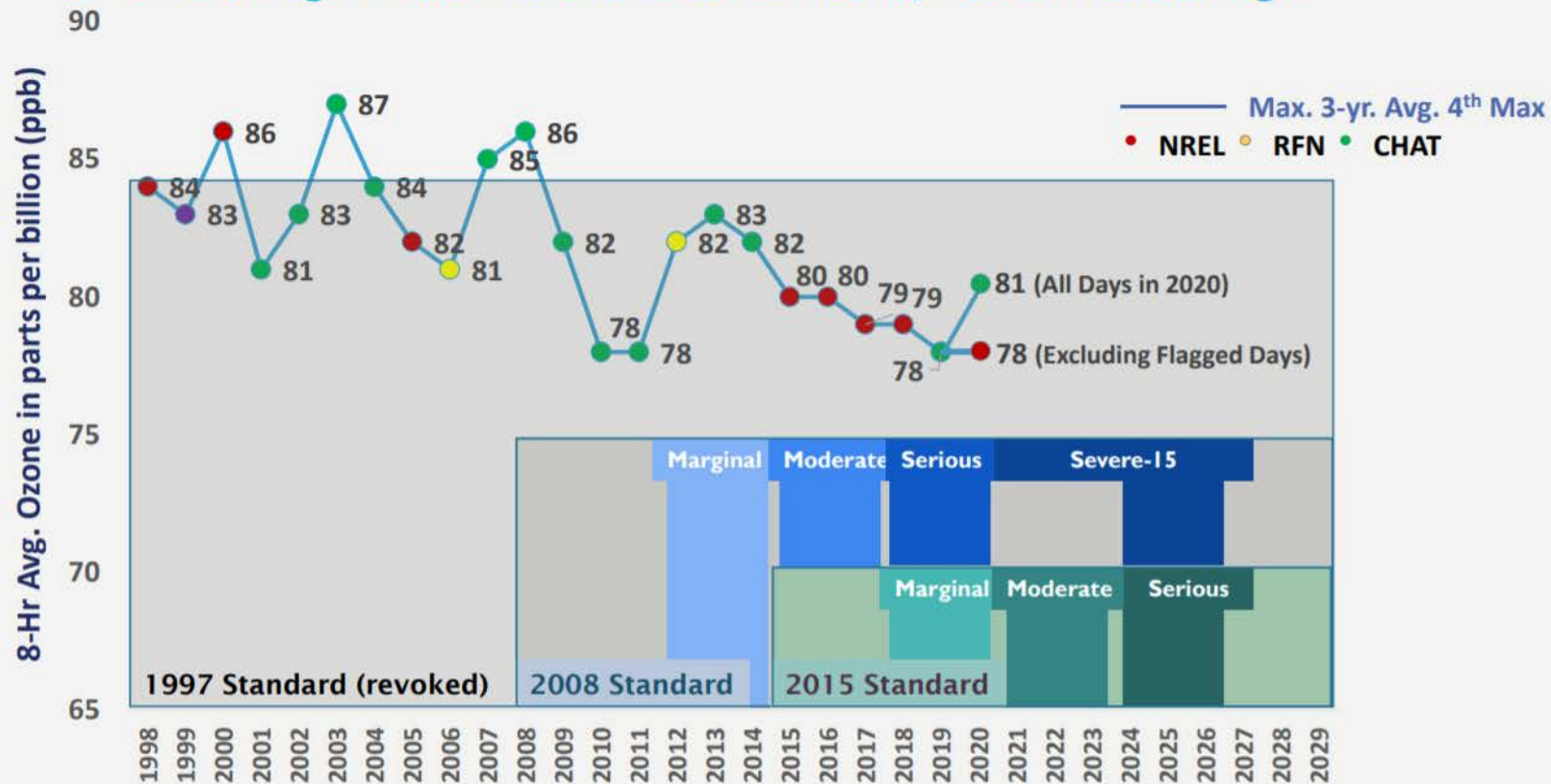
# Ozone Nonattainment History

- 1971:** EPA establishes National Ambient Air Quality Standards (NAAQS) for several air pollutants including ozone
  - 1997:** EPA promulgates 8-hour ozone standard of 80 parts per billion (ppb)
  - 2004:** EPA designates Denver Metro/North Front Range (DM/NFR) as nonattainment for 1997 standard
  - 2008:** EPA lowers ozone standard to 75 ppb
  - 2012:** EPA classifies DM/NFR as "marginal" nonattainment for 2008 ozone standard
  - 2015:** EPA lowers ozone standard to 70 ppb
  - 2016:** DM/NFR region moved from "marginal" to "moderate" ozone nonattainment for the 2008 standard
  - 2018:** EPA classifies DM/NFR as "marginal" nonattainment for 2015 ozone standard
  - 2020:** EPA classifies DM/NFR as "serious" nonattainment for 2008 ozone standard
  - 2021/2022:** Due to high ozone levels in July and August 2020, the area may be reclassified as "severe" under the 2008 standard and "moderate" under the 2015 standard in late 2021 or early 2022
- 



# 8-HOUR OZONE TRENDS AND FEDERAL STANDARDS

## 3-Year Design Values in the Denver Metro/North Front Range



8-Hour Ozone Standard: Based on a three-year average of the annual forth-highest daily 8-hour maximum ozone concentration.  
\*Current as of 10/30/20.

# 2020 Ozone Summary

Denver Metro/North Front Range Area - 2020 8-Hour Ozone Summary\*  
Through 09/30/20

Monitor	1st Max 2020	2nd Max 2020	3rd Max 2020	4th Max			2018- 2020 Design Value^
				2020	2019	2018	
Chatfield State Park	89	88	88	83	78	83	81
	08-23-20	08-22-20	08-21-20	08-26-20			
NREL	90	90	88	87	75	80	80
	08-23-20	08-21-20	08-22-20	08-25-20			
Rocky Flats	89	86	84	84	72	81	79
	08-23-20	08-21-20	07-10-20	06-17-20			
Fort Collins - West	81	77	76	75	71	81	75
	08-23-20	08-21-20	08-22-20	04-17-20			
Highland	89	87	85	83	73	77	77
	08-23-20	08-22-20	08-21-20	08-24-20			
Boulder Reservoir	79	77	76	76	69	77	74
	08-25-20	04-17-20	08-22-20	08-13-20			

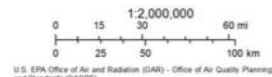
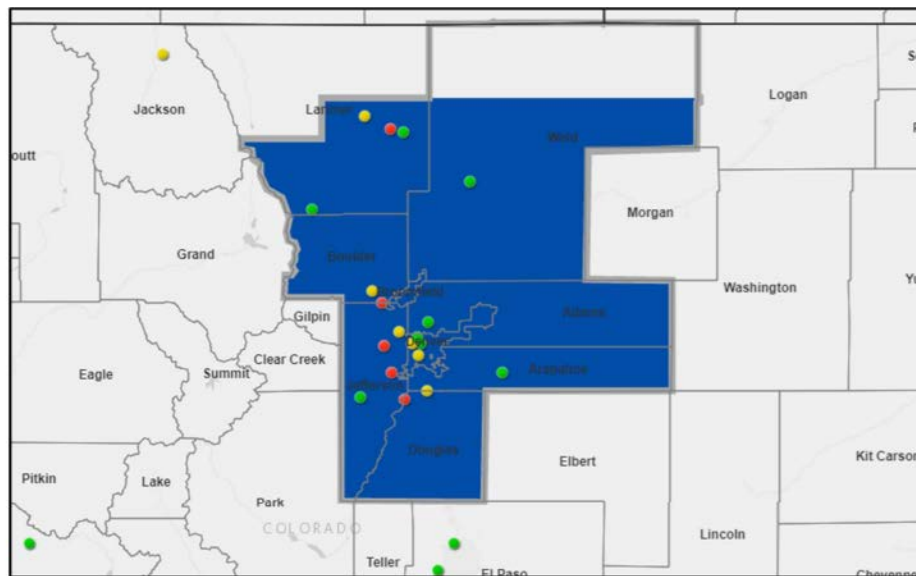


# Ozone Nonattainment Area Boundary

- In 2020, U.S. Court of Appeals for the District of Columbia Circuit found that the EPA incorrectly excluded northern Weld County from Colorado's nonattainment map
- Lawsuit brought by the BOCC, the Center for Biological Diversity and other environmental groups
- Ruling brought issue back to the EPA and on May 24, 2021, EPA proposed to include northern Weld County
- EPA is accepting comments on the proposal



# DM/NFR Ozone Nonattainment Area



# Boulder Reservoir Air Monitoring Study

- Contracted with CU's INSTAAR in 2017 with BOCC funding
- Current contract with Boulder A.I.R. - Dr. Detlev Helmig - funded by Sustainability Tax
- Enables Boulder County to quantify and better understand impacts of oil and gas emissions on air quality
- $\text{NO}_x$ , VOCs and methane monitored
- Co-located with state's ozone monitor



# CURRENT AIR MONITORING PROGRAMS



Boulder Reservoir (BRZ) Website



Longmont Union Reservoir (LUR) Website



Broomfield Soaring Eagle Park (BSE) Website



Toolik Alaska (TFS) Website



Longmont Municipal Airport (LMA) Website



Broomfield Livingston (BLV) Website



## Current Weather and Atmospheric Chemical Conditions in Boulder, Colorado

Boulder



Atmosphere  
Innovation  
Research

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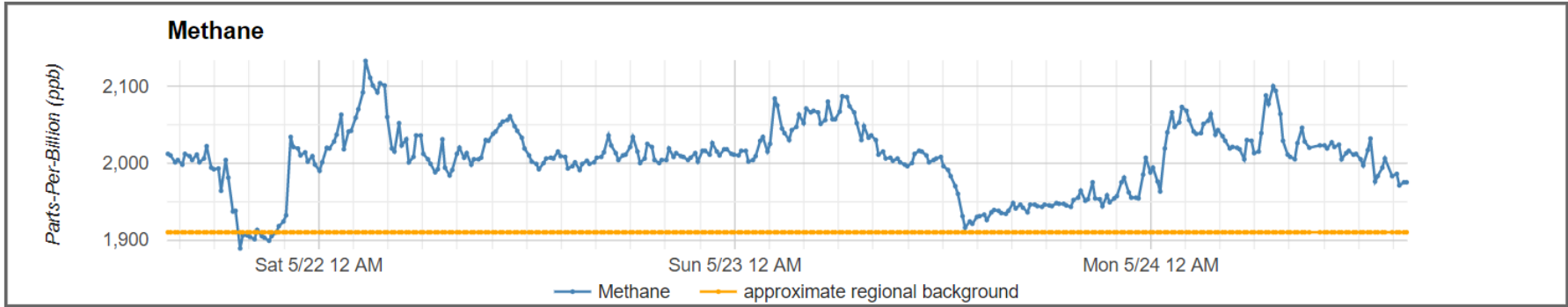
### Methane, Volatile Organic Compounds, Ozone, and Nitrogen Oxides at the City of Boulder Reservoir (Colorado)

This site presents preliminary results of atmospheric near-real time monitoring at the Boulder Reservoir. This monitoring is sponsored by Boulder County Public Health. Monitoring is conducted by researchers at Boulder A.I.R. LLC, in partnership with the Colorado Department of Public Health and the Environment (CDPHE)

#### Methane (CH<sub>4</sub>)

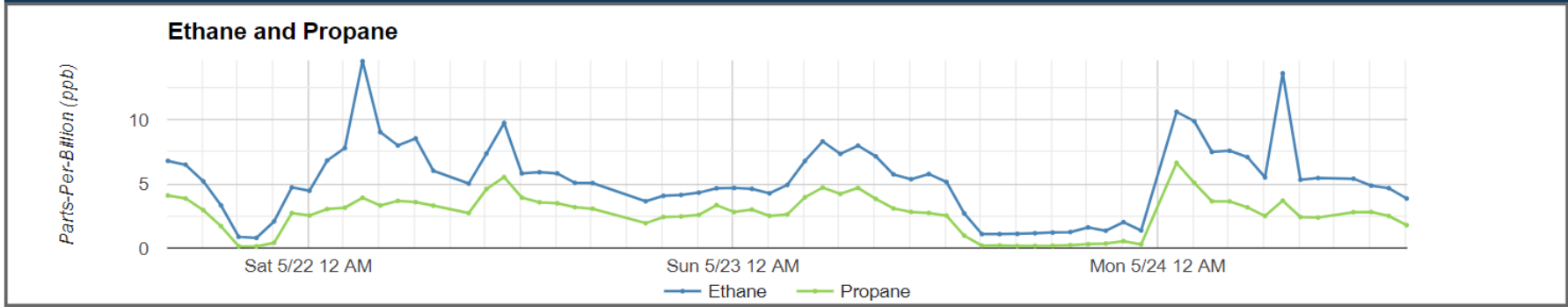


Methane (CH4)



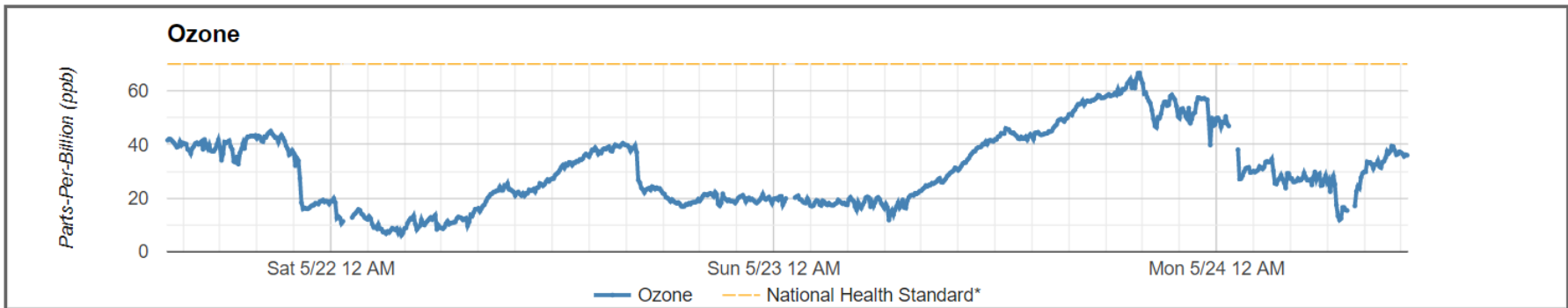
Methane is a potent greenhouse gas. It has an atmospheric lifetime of about a decade and is distributed globally. Methane emissions in our area mainly come from oil and gas. Livestock, landfills, and wastewater treatment plants are also sources of methane in northeastern Colorado.

Selected Volatile Organic Compounds (VOCs)



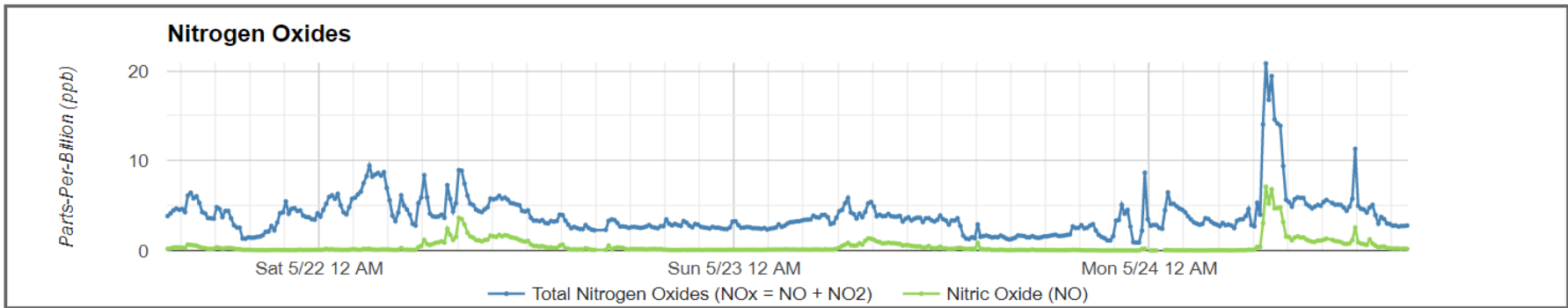


## Ozone (O<sub>3</sub>) (Preliminary data provided by CDPHE)



All CDPHE data are collected real-time and have not been corrected nor validated. \* The dotted line in the ozone graph indicates the 70 ppb National Ambient Air Quality Standard (NAAQS). Exceedance of the standard occurs when the 8-hour running mean of the ozone readings is equal to or higher than this value.

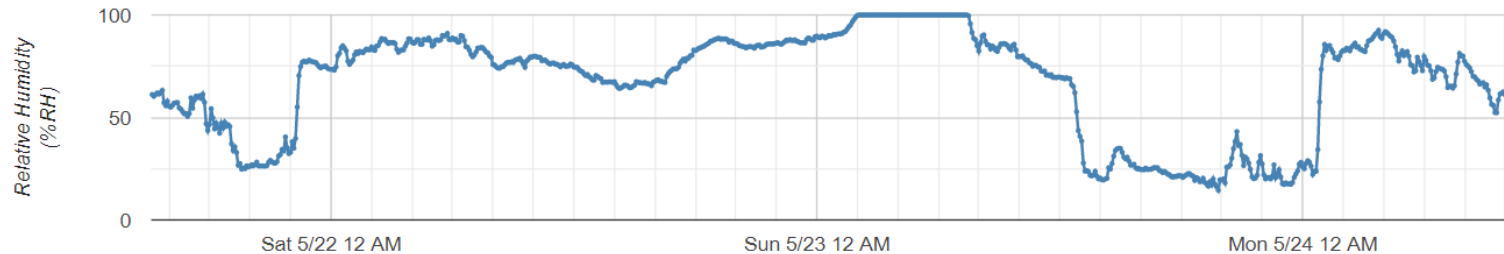
## Nitrogen Oxides (NO<sub>x</sub>)



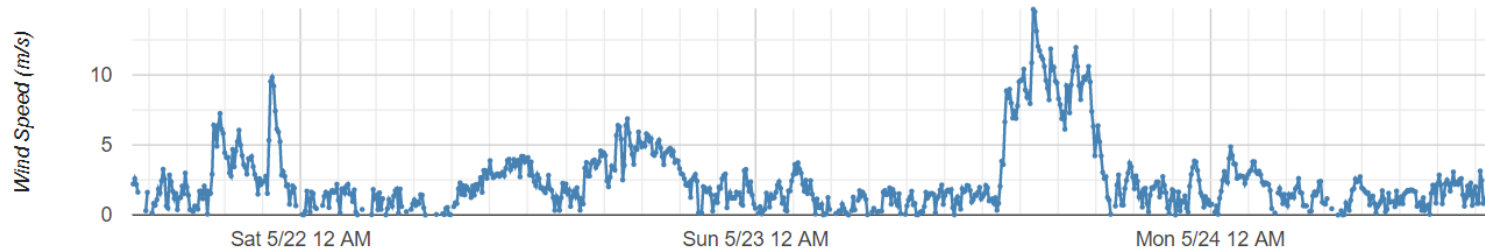
Nitrogen oxides (NO<sub>x</sub> = NO<sub>2</sub> + NO) react in the atmosphere to form ozone, nitric acid, and particulate nitrate.

Nitrogen oxides are formed during high temperature combustion in engines and fossil-fuel fired power plants.

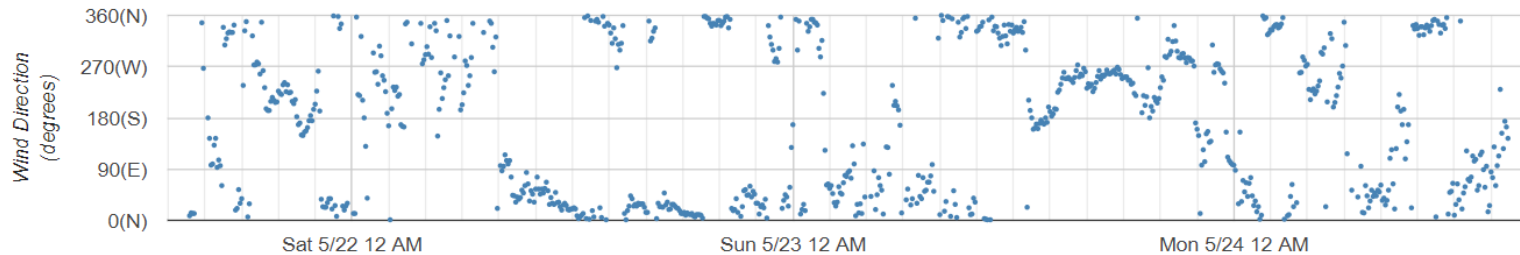
### Relative Humidity



### Wind Speed



### Wind Direction



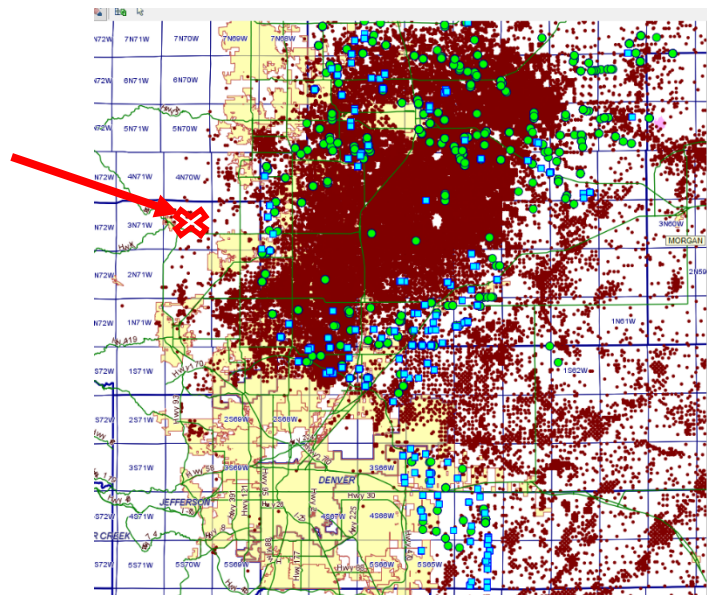
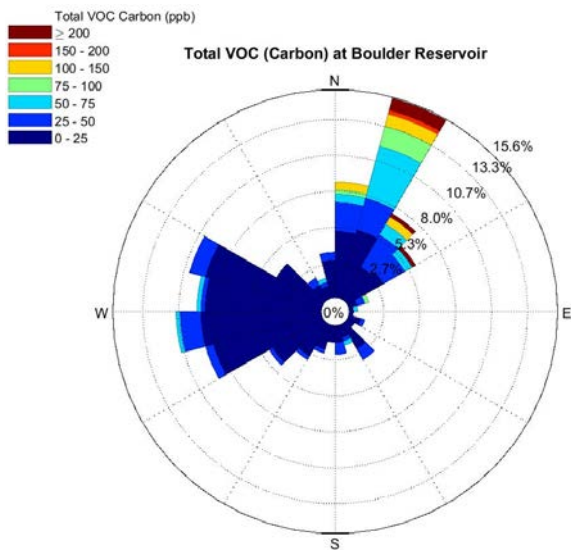


# Study Findings Overview

- High correlation between concentrations and air transport
- Impacts from the Northeast of site
- Link between ozone exceedances and emissions

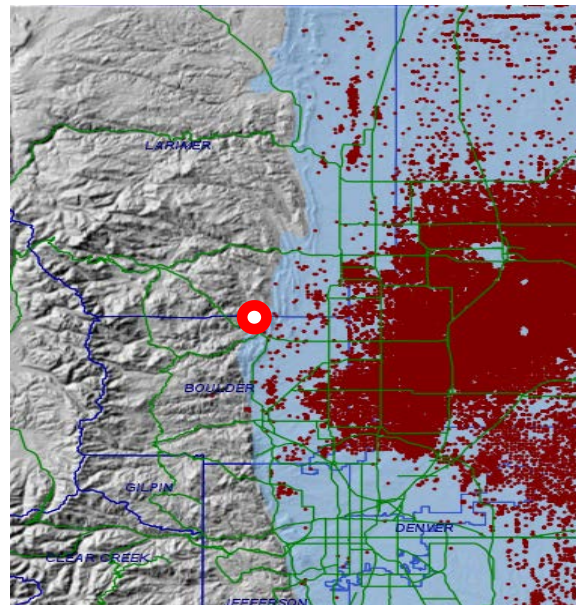
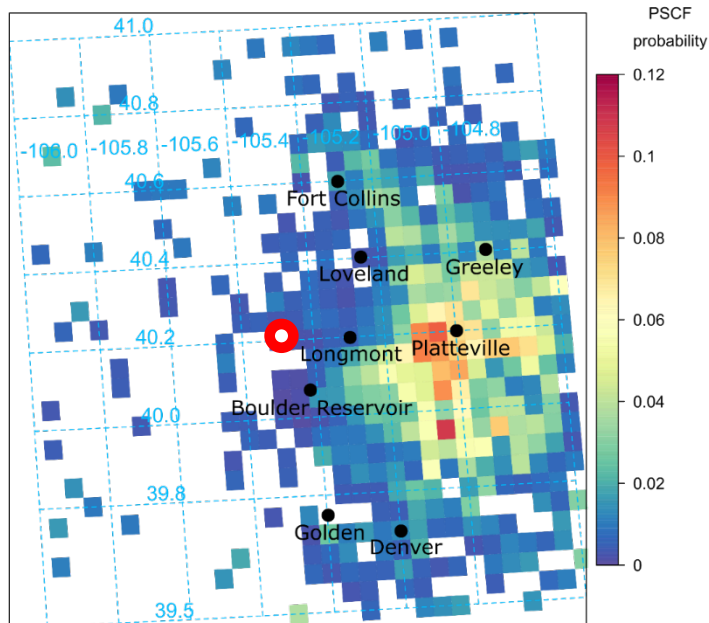


# Concentrations and Wind Direction



# Footprint Analysis

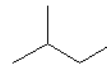
Probability  $O_3 > 70$  ppb standard  
(Apr 2017-Dec 2018)



# Oil & Gas Fingerprint



i/n-Pentane  
Ratio



*iso*-Pentane



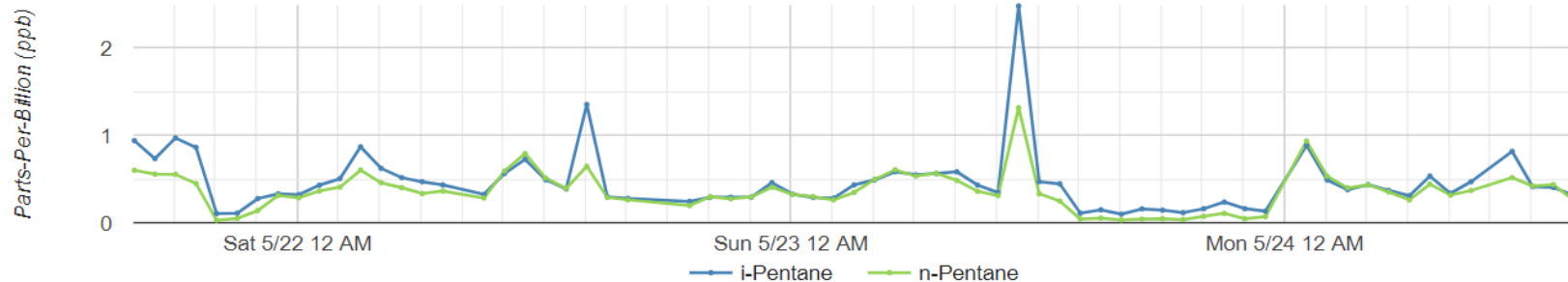
*n*-Pentane

0.9

2.5

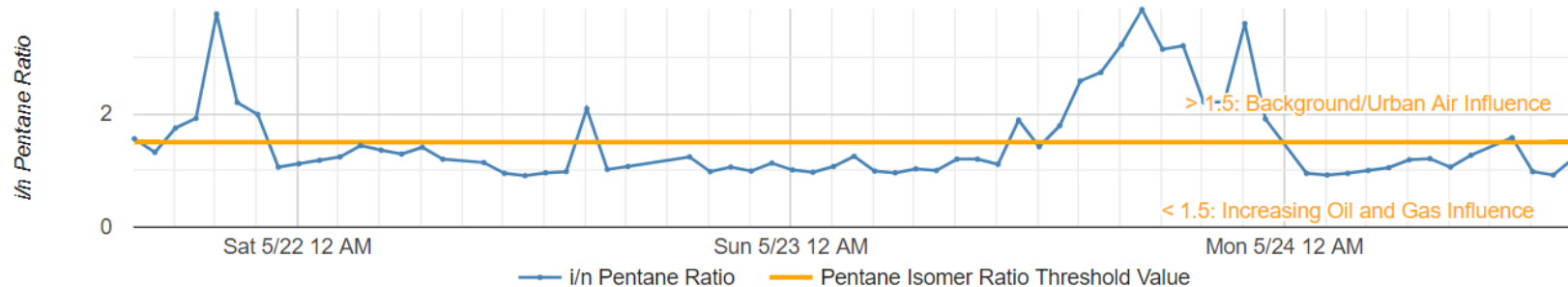


## Pentane Isomers



Pentanes are also contributors to ozone formation on local to regional scales.  
Pentanes are primarily emitted from gasoline vapors and oil and gas production.

## i/n Pentane Ratio



Because i-pentane and n-pentane are released in different relative quantities by different sources, the i/n pentane ratio can be used to separate the influence of urban emissions from oil and gas emissions ([Gilman, 2013](#); [Thompson, 2014](#)). An i/n pentane ratio of 0.8 - 0.9 is typical of raw oil and gas emissions, whereas a ratio from 2-4 is characteristic of vehicle and urban emissions. In recent years, Boulder's average pentane ratio has been around 1.1 ([Gilman, 2013](#)), suggesting a mix of influences from vehicle, urban, and oil and gas emissions.



# CSU Source Apportionment Study

- Source attribution of VOCs at Boulder Reservoir determined using two analysis methods
- High ozone is associated with oil and gas producing regions
- Surface ozone in the DMNFR is heavily influenced by local sources, most of all oil and gas emissions
- Trends in ozone precursor emissions and surface ozone do not show dramatic decreases in VOC and NO<sub>x</sub> emission

*Seasonality and source apportionment of non-methane volatile organic compounds at Boulder Reservoir between 2017 and 2019*







# Wildfire Smoke and Ozone

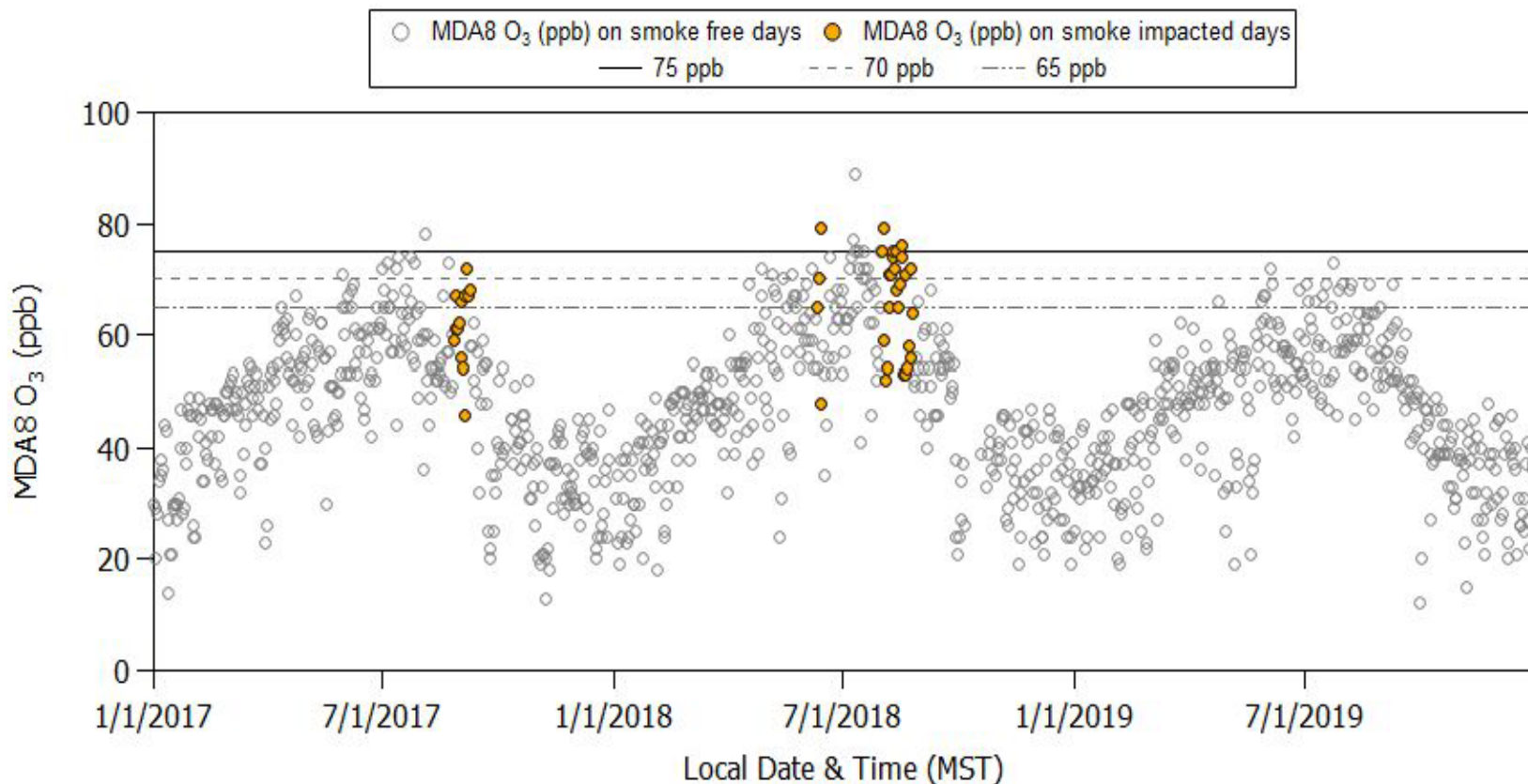
- Local sources of ozone precursors are a predominant cause of high ozone days at Boulder Reservoir rather than smoke events or non-local emissions
- Weekend-weekday differences in the observations indicate a transition to NO<sub>x</sub>-limited ozone production

*Weekend-weekday implications and the impact of wildfire smoke on ozone and its precursors at Boulder Reservoir, Colorado between 2017 and 2019*





# Wildfire Smoke and Ozone



# Putting Study Findings to Use

- Positions and testimony to support strengthened oil and gas regulations by the AQCC
- Public messaging on the status of air quality and climate impacts in and near Boulder County
- Comments to EPA supporting the need to tighten national controls on oil and gas
- Inform policy and technical input to the Colorado Energy Office, COGCC, CDPHE, RAQC and more