Public Health

Boulder Reservoir Air Monitoring Study Results

Executive Summary -- June 2019

The Boulder Reservoir air monitoring study, sponsored by Boulder County, is led by Dr. Detlev Helmig of the University of Colorado Boulder's Institute of Arctic and Alpine Research (INSTAAR) as the Principal Investigator. The study began in February 2017. The Colorado Department of Public Health and Environment (CDPHE) has been a partner in this project, allowing INSTAAR to place their equipment in the state's monitoring shed. Earthworks funded the project from September – December 2018 during a gap in county funding. The following is a summary of Dr. Helmig's presentation to the Regional Air Quality Council on May 3, 2019, which summarized the study findings thus far.

Pollutants Measured

Since mid-February 2017, the INSTAAR researchers have measured methane and nitrogen oxides (NO_X) on a continuous (24/7) basis using equipment at Boulder Reservoir.

- More than 200,000 NO_X measurements have been collected, and
- More than 60,000 methane measurements have been collected.

Since early April 2017, volatile organic compounds (VOCs) have been monitored. Altogether, sixteen VOCs are quantified, including species, such as ethane, propane, and benzene.

- More than 9,000 VOC samples have been analyzed.

CDPHE monitors ozone at the Boulder Reservoir within the same enclosure as INSTAAR's instruments, which provides the opportunity to compare the measurements of ozone and its precursors. These data are available in graphical form on the INSTAAR maintained project website.

For this study, ethane is used as an indicator of oil and gas sources because they are the only significant source of ethane emissions. In addition, researchers are using the iso-Pentane/n-Pentane (i/n pentane) ratio as an indicator of oil and gas influence on the monitoring data. An increasing ratio shows an increased urban vehicle influence, while a decreased ratio shows increased oil and gas influence on the air monitor.

Significant Findings

This monitoring project has provided invaluable data that are and will continue to be used at the local and state level to support the need for better emission controls on oil and gas sources. Significant findings are:

- Oil and gas tracer pollutants and total VOCs are highly variable at the Boulder Reservoir monitoring site. Frequent occurrences of air plumes with highly elevated VOC concentrations, with up to 100-fold increases over background levels, have been observed. The data show a high correlation between highly elevated concentrations and air pollution transport events from oil and gas regions.
- Consistent interpretations with three different data analysis approaches found much higher VOC pollutants coming from northeast of the monitor location. Oil and gas operations are highly concentrated in Weld County, to the northeast of the monitoring site.
- Air transported from oil and gas regions brings in elevated VOC levels. The source region for VOCs overlaps with the source region for high ozone occurrences, which strongly suggests that oil and gas emissions contribute significantly to exceedances of the ozone standard at the Boulder Reservoir monitoring site.

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- Higher methane and VOC concentrations were recorded in 2018 than in 2017.

Pollutant Concentrations are Dependent on Wind Direction

Wind direction has proven to be the strongest predictor of hourly air quality at the Boulder Reservoir monitor. Strong winds from the west tend to carry the lowest pollutant levels of any samples, while moderate to strong winds from the northeast tend to carry the highest pollutant levels.

- Monitoring data show a strong correlation between wind speed and direction and measured methane, ethane, propane, and a shift in the i/n pentane ratio. Air transported from the north to southeast sector during most times has a strong oil and gas emissions signature.
- The methane concentrations and ethane and propane levels decrease when the wind direction changes to northwesterly from the prevailing northeasterly winds.

Results indicate a strong correlation between air quality in the area and oil and natural gas development in neighboring Weld County, with northeasterly winds reliably bringing higher levels of ethane, propane, and methane that are not attributable to vehicles. The recorded total VOC concentrations show the dependence on wind direction, with higher total VOC levels recorded with northeasterly winds. This comparison has also been done for each specific VOC (ethane, benzene), and the isomeric pentane ratio, with the same results.

- Back trajectory analyses (using National Oceanic and Atmospheric Administration (NOAA) Hysplitt) show that:
    - High ethane and propane events can be traced back to sources from the east and northeast of the monitoring site.
    - Comparing the Boulder Reservoir site to data from Niwot Ridge (in the mountains to the west of Boulder), ethane levels are much higher at Boulder Reservoir. Trajectory analyses do not show emissions coming from the west to Boulder.

Methane and VOC Comparisons of 2018 and 2017 Data Show Higher Methane in 2018

A comparison between methane changes in westerly versus easterly winds shows that methane increases were relatively higher in easterly transport in 2018. In five out of six comparisons, methane levels were higher in transport from the east sector compared to the west sector. This implies that it is more likely that oil and gas methane emissions have increased rather than decreased. Furthermore, in three out of four comparisons, oil and gas VOC tracer pollutant concentrations were higher in 2018 than in 2017.

Emission Inventories Indicate No Decrease in Emissions

Scaling of the VOC monitoring data to NOAA Denver-Julesburg methane flux estimates yields a total combined methane and VOC emissions estimate of 292,000 tons per year, which is equivalent to natural gas used per year by 146,000 households. This hydrocarbon mass is equivalent to 2,300,000 barrels of oil and tailpipe emissions from around 70 million cars. Benzene emissions are estimated to be 620 tons per year from oil and gas sources. The VOC emission estimate for total VOCs is 134,000 tons per year, compared to the Regional Air Quality Commission (RAQC) 2017 inventory of 56,200 tons per year. (The RAQC is working on updating this inventory for the new ozone State Implementation Plan.)

For comparison, analyses of three different emissions studies conducted by aircraft in the Denver-Julesburg Basin show no indication of a decreasing oil and gas methane emissions trend. There is also no indication of a change in the oil and gas VOC/methane ratio, and therefore no indication of a change in VOC emissions.

Air Transported from Oil and Gas Regions Dominates in Transport of High Ozone
Air transported from oil and gas regions to the northeast of the Boulder Reservoir monitor brings in elevated VOC levels and contributes significantly to exceedances of the ozone standard. Probability analyses show significant impacts from the northeast, but limited impacts from any other direction, including Denver.

Preliminary Modeling Analysis Shows Influence of Oil and Gas Sources
The CU Mechanical Engineering program, under the direction of Dr. Jana Milford, conducted a preliminary modeling analysis of the first year of data. This preliminary analysis shows an overwhelming influence at the monitoring site from oil and gas sources, as indicated by the total non-methane VOCs. Overall results for all summer morning (morning data were chosen because concentration peaks normally occur during morning hours; winter data were analyzed as well with similar results) data show:

- Produced natural gas accounts for 51% of total non-methane VOCs.
- The condensate tank category accounts for 30% of total VOCs.
- Gasoline exhaust is responsible for 13% of the VOC data.

Boulder County Public Health is pursuing funding for a more robust modeling analysis of the complete data set from the first 18 months of the monitoring study.

Attachment: Dr. Detlev Helmig, INSTAAR, “Air Quality Impacts from Oil and Natural Gas Emissions in the Northern Colorado Front Range,” presented to the RAQC Board on May 3, 2019.