M.S. Defense Announcement
Emily Lachenmayer
Monday, March 28, at 10:00 a.m.

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March 28, 2022
10:00 a.m.

Defense
CIRA Director's Conference Room (135 CIRA) or Virtual

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Jeffrey L. Collet, Jr. (Adviser)
Emily Fischer
Anthony Marchese (Mechanical Engineering)

Impacts of oil and natural gas development and other sources on volatile organic compound concentrations in Broomfield, Colorado

In 2017 substantial new oil and natural gas (ONG) extraction was approved by the City and County of Broomfield (CCOB). A monitoring program was established by CCOB to determine how new ONG extraction impacted local air quality. Multiple instruments were utilized to monitor air quality in the county including weekly volatile organic carbon (VOC) sampling canisters deployed across CCOB by Colorado State University and Ajax Analytics and hourly VOC, methane, and criteria pollutant measurements taken by the Colorado Air Monitoring Mobile Lab (CAMML) deployed near an ONG well-pad by the Colorado Department of Public Health and Environment (CDPHE). Weekly samples, collected from October 2018 through December 2020 were analyzed for 52 VOCs using a 5-channel gas chromatograph. The CAMML reported 20 VOCs, methane, PM2.5, PM10, nitrogen oxides (NO_x), and ozone. Positive Matrix Factorization (PMF) was applied to both datasets to characterize key air pollution sources and their impacts in space and time.

Six factors were found to describe the weekly data best: Background (biogenic), Combustion, Light Alkane, Complex Alkane, a Drilling factor, and an Ethyne factor. Contributions of the ONG-related PMF factors increased most strongly near well-pads during particular ONG pre-production activities. The Light Alkane factor was most active during production and coiled tubing operations, and flowback at one or more of the new well-pads. The Complex Alkane factor was strongly associated with drilling and coiled tubing operations and flowback at one of two well-pads. The Drilling factor contained a VOC profile that closely matched volatiles released from a drilling mud (lubricant for the drill bit) used at two of the three sites. The Ethyne profile represents an unknown and previously undocumented source composition originating from a well-pad. This ethyne and benzene-rich emission was independently observed in other CCOB air monitoring efforts.

Five factors best explained the hourly CAMML data; these factors resembled those derived from PMF analysis of the weekly data set. Three factors, Combustion, Ozone background, and Particulate Matter, were not found to be related to local ONG extraction while the profiles containing many of the alkane species (Light Alkane factor and Complex Alkane factor) showed correlation with pad activities. Wind direction analysis suggests emissions associated with these factors were transported from the pad.

Benzene was a particular focus of the study given its potential health effects at modest concentration levels. On average, the source factors contributing most to benzene were combustion (38%), longer-lived alkanes from ONG production (22%), and shorter-lived alkanes from ONG production (16%). ONG activities contributed more strongly to benzene levels during pre-production and production phases.

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