Ph.D. Defense Announcement
I-Ting Ku
Wednesday, January 10, at 1:00 pm

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Ph.D. Defense

January 10, 2024
1:00 pm

Defense
ATS Large Classroom (101 ATS) or Teams

Post Defense Meeting
Riehl Room (211 ACRC)

Committee:
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AIR QUALITY IMPACTS FROM UNCONVENTIONAL OIL AND GAS DEVELOPMENT

Unconventional oil and natural gas development (UOGD) has expanded rapidly across the United States raising concerns about associated air quality impacts. While significant effort has been made to quantify and limit methane emissions, relatively few observations have been made of emitted Volatile Organic Compounds (VOCs). Extensive air monitoring during development of several large, multi-well pads in Broomfield, Colorado, in the Denver-Julesburg Basin, provides a novel opportunity to examine changes in local concentrations of air toxics and other VOCs during drilling and completions of new wells. With simultaneous measurements of methane and 50 VOCs from October 2018 to December 2022 at as many as 19 sites near well pads, in adjacent neighborhoods, and at a more distant reference location, we identify impacts from each phase of well development and production.

In Part 1, we report how emissions from Broomfield pre-production and production operations influence air toxics and other VOC concentrations at nearby locations. Use of weekly, time-integrated canisters, a Proton Transfer Reaction Mass Spectrometer (PTR-MS), continuous photoionization detectors (PID) to trigger canister collection upon detection of VOC-rich plumes, and an instrumented vehicle, provided a powerful suite of measurements to characterize both transient plumes and longer-term changes in air quality. Prior to the start of well development, VOC gradients were small across Broomfield. Once drilling commenced, concentrations of oil and gas (O&G) related VOCs, including alkanes and aromatics, increased around active well pads. Concentration increases were clearly apparent during certain operations, including drilling, coil tubing/millout operations, and production tubing installation. Emissions of C8-C10 n-alkanes during drilling operations highlighted the importance of VOC emissions from a synthetic drilling mud chosen to reduce odor impacts. More than 90 transient plumes were sampled and connected with specific UOGD operations. The chemical signatures of these plumes differed by operation type. Concentrations of individual, O&G-related VOCs in these plumes were often several orders of magnitude higher than in background air, with maximum ethane and benzene concentrations of 79,600 and 819 ppbv, respectively. Study measurements highlight future emission mitigation opportunities during UOGD operations,

including better control of emissions from shakers that separate drill cuttings from drilling mud, production separator maintenance operations, and periodic emptying of sand cans during flowback operations.

In Part 2 OH reactivities (OHR) were calculated to examine the potential of emitted VOCs to contribute to regional ozone formation. NO2 was the largest contributor to OHR during winter when OHR values peaked, while VOCs dominated OH sinks during summer. Oxygenated VOCs and C3-C7 n-alkanes, closely associated with O&G activities, were primary contributors to OHR levels during the summer ozone season. In Part 3 we leverage observations from Broomfield and other Colorado O&G air quality studies to examine relationships between O&G emissions of methane and VOCs. A key goal is to determine whether more commonly measured methane emissions can serve as a surrogate to estimate emissions of less frequently measured compounds such as benzene, a key air toxic. While strong correlations are observed between benzene and methane emissions in some situations, considerable variability is observed in this relationship across locations and operations suggesting caution in assuming that reductions in methane emissions will yield proportionate reductions in releases of air toxics.