UtahStateUniversity
BINGHAM RESEARCH CENTER

UINTA BASIN AIR QUALITY RESEARCH PROJECT

2019 Annual Report—Executive Summary

BACKGROUND INFORMATION ABOUT UINTA BASIN AIR QUALITY

- Ozone negatively impacts respiratory health, especially for those with lung diseases. Because of its impacts on health, EPA regulates ozone in ambient air.
- Ozone concentrations have exceeded the EPA standard of 70 parts-per-billion (calculated as the daily maximum 8-hour average) during some winters in the Uinta Basin, and EPA declared parts of the Basin a non-attainment area for ozone in 2018.
- The number of ozone exceedance days and concentrations of ozone that occur each year are closely tied to meteorology. Years with persistent snow cover and high barometric pressure tend to have more days with strong winter inversions and high ozone. During inversion episodes, ozone concentrations tend to be higher at lower elevations where inversion conditions are stronger and last longer. In the absence of winter inversions, ozone concentrations in the Basin are similar to those in other rural, high-elevation locations around the western United States.
- Ozone is formed from chemical reactions involving pollutants emitted to the atmosphere. The Basin has about 10,000 oil and gas wells, and the oil and gas industry is the largest local contributor of ozone-forming emissions.

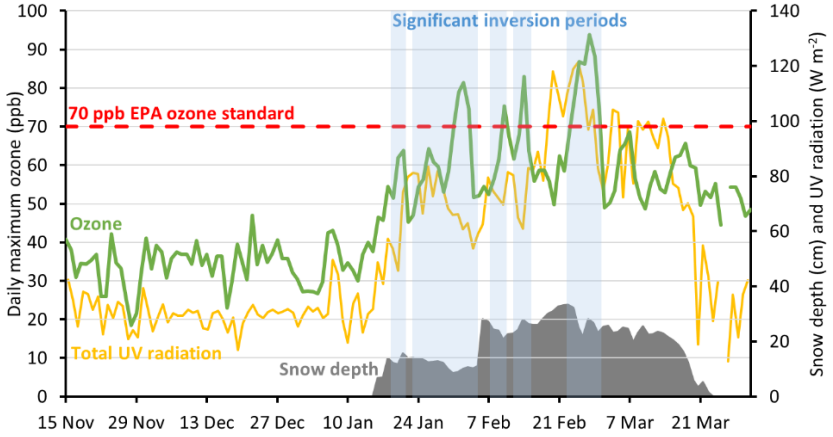
PURPOSE OF THE UINTA BASIN AIR QUALITY RESEARCH PROJECT

- The occurrence of wintertime ozone in rural areas like the Uinta Basin has only been known to science since 2006, and the Uinta Basin is one of only two regions in the world where wintertime ozone is known to occur (the other is Wyoming's Upper Green River Basin). Because of this, many aspects of the meteorology, chemistry, and emissions that allow ozone to form during winter are still poorly understood.
- Federal and state agencies are required by law to promulgate regulations that reduce ozone-forming emissions in the Uinta Basin. These regulations will mostly target the local oil and gas industry, which is the basis for the majority of the Basin's economy.
- Scientific research to better elucidate the causes and characteristics of winter ozone can help industry and regulators craft emissions reductions that maximize effectiveness and minimize costs to the local industry and economy.
- Recognizing this, in 2016, the Utah Legislature tasked Utah State University's Bingham Research Center with conducting research to improve understanding of winter ozone in the Uinta Basin. This research is to include the following:
    - Collection and analysis of ambient air measurements of meteorology and chemistry,
    - Improvement of air quality computer models that are used by industry and regulators to develop emissions control strategies, and
    - Characterization of emission sources through measurements and analysis.
- To ensure that winter ozone research is useful and relevant, the USU Bingham Center partners with and receives guidance and input from government agencies, industry, and other stakeholders as it plans and executes various research projects.

seth.lyman@usu.edu 435.722.1740 binghamresearch.usu.edu

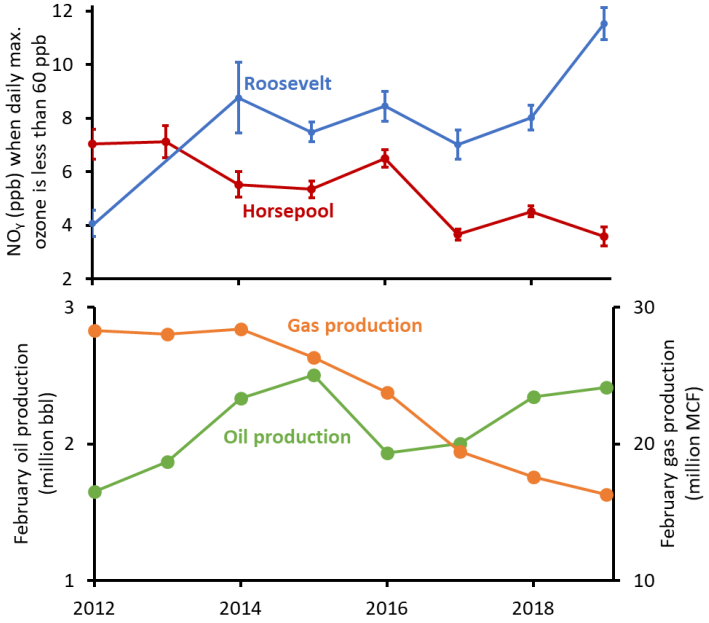
2019 RESEARCH HIGHLIGHTS

- *Ozone during previous winter:* During winter 2018-19, ozone in the Uinta Basin exceeded the EPA standard of 70 ppb on 16 days. Because of this high ozone, the Uinta Basin's non-attainment status is very likely to be changed from marginal to moderate, triggering additional emission control requirements and other regulatory actions. The status change to moderate will occur in 2021.



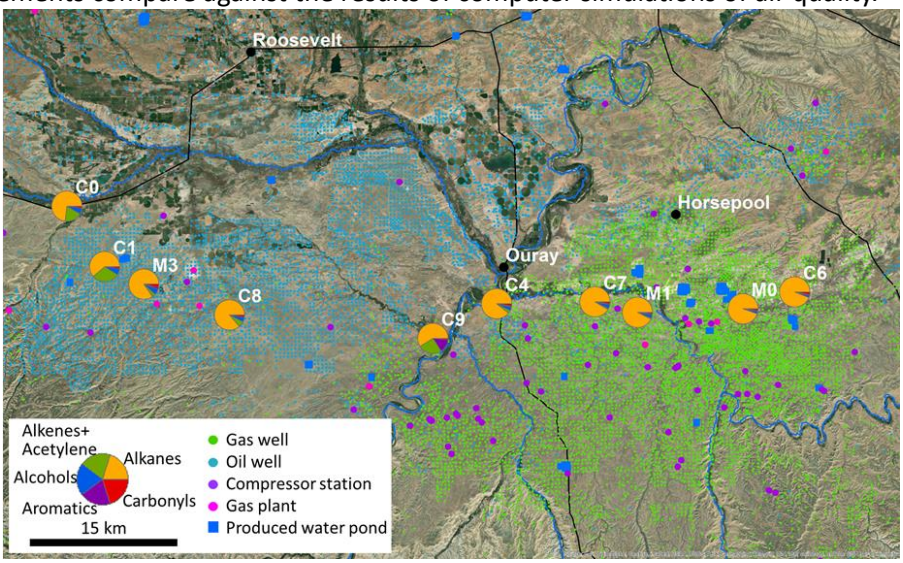
Ozone, snow depth, and daytime average total UV radiation during winter 2018-19. Inversion periods are shown as light blue boxes.

- *Changes over time:* As the oil and gas industry changes, the spatial distribution of ozone and its precursors around the Uinta Basin also change. Concentrations of ozone-forming pollutants in the atmosphere are decreasing in the eastern Basin, which is dominated by natural gas development because prices are low and natural gas production is declining. In the western Basin, where oil production is dominant, ozone precursor concentrations have begun to increase. Ozone precursor concentrations have decreased in the Basin overall, and statistical analyses show that ozone during winter 2018-19 would have been worse if those decreases had not occurred.



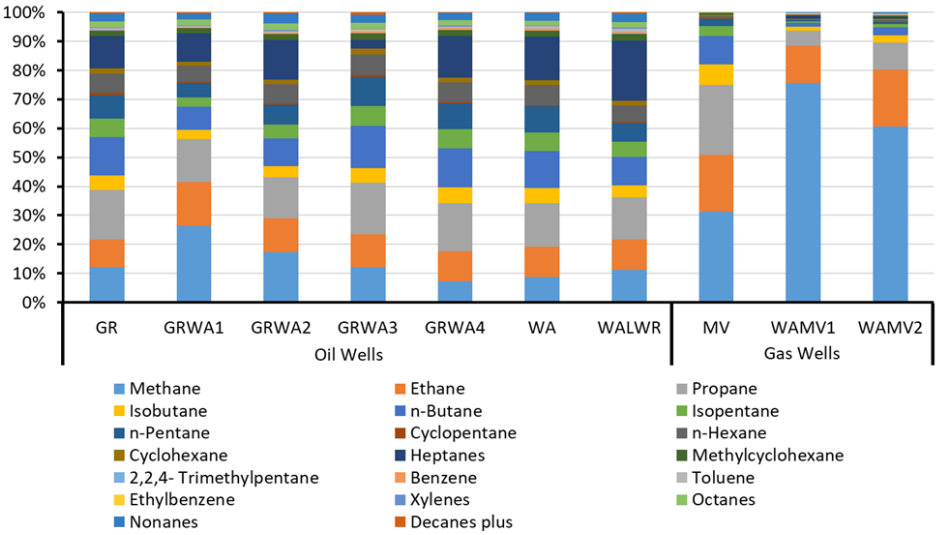
Average NO_Y (an ozone precursor) at Horsepool and Roosevelt for each winter (top panel), and basin-wide February oil and gas production (bottom panel). Horsepool and Roosevelt are in the eastern and western Uinta Basin, respectively.

- *Organic compounds in transect:* Measurements of 76 organic compounds in ambient air were collected at a network of measurement stations across the Uinta Basin. These measurements showed that concentrations of alkenes, a class of hydrocarbons that are very active in ozone production, are relatively high in the western Basin, and evidence points to natural gas-fueled pumpjack engines as the probable source. Future work, made possible by funding from the Utah Division of Air Quality (UDAQ), will provide additional measurements and explore how these measurements compare against the results of computer simulations of air quality.



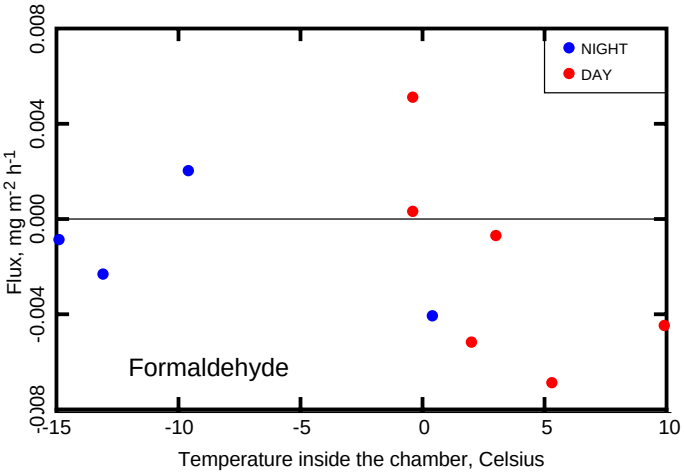
Composition (percent by volume) of organic compounds measured at stations in a transect across the Uinta Basin on 27 February 2019.

- *Emissions composition:* New measurements of organic compound emissions from liquid storage tanks and other oil and gas sources have improved understanding of the composition of organic compound emissions. These measurements include a new, unique system developed at USU to measure emissions directly. UDAQ led and provided the majority of funding for this study.



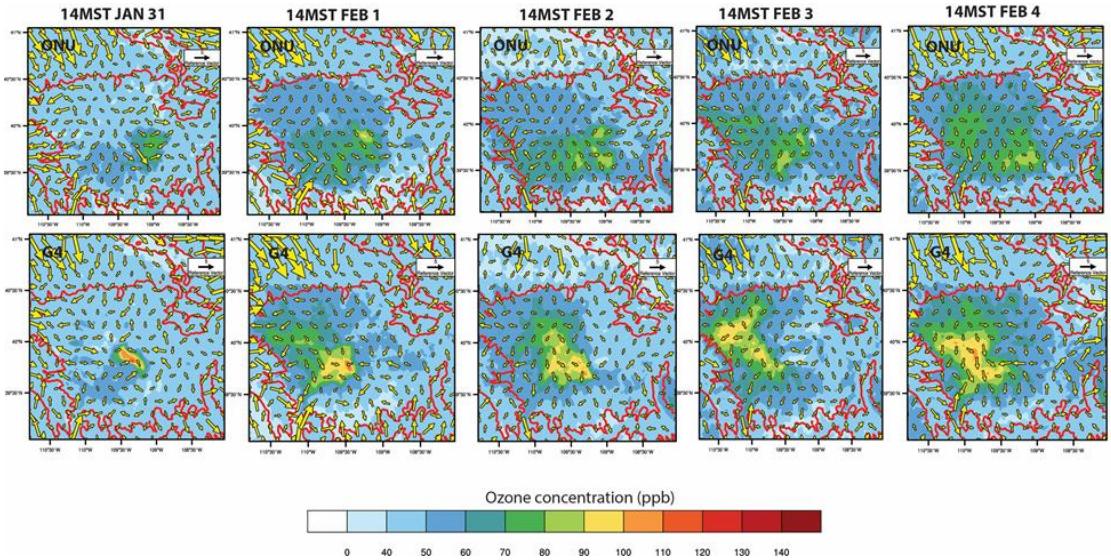
Formation-averaged hydrocarbon composition of emissions from liquid storage tanks at oil and gas wells. GR is the Green River formation, GRWA is Green River-Wasatch (multiple profiles exist), WA is Wasatch, MV is Mesa Verde, and WAMV is Wasatch-Mesa Verde.

- *Aldehydes emitted from snow:* Under some conditions, snow can release formaldehyde and acetaldehyde, two important ozone precursors, into the atmosphere. Emissions from snowpack may even be converting less reactive organic compounds into formaldehyde and acetaldehyde, enhancing the ability of the atmosphere to produce wintertime ozone.

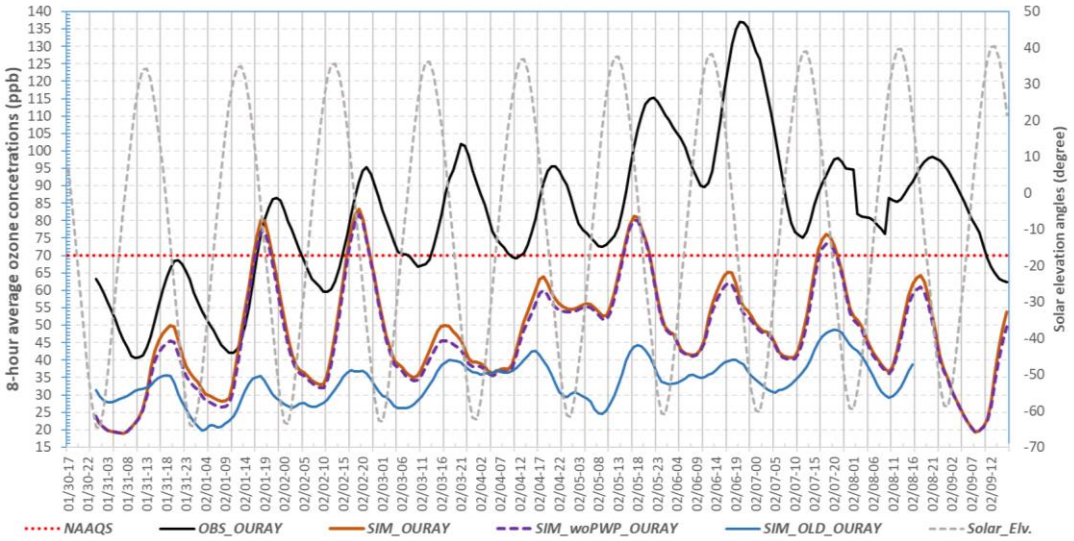


Fluxes of formaldehyde through the air-snow interface as a function of temperature, as measured by a flux chamber.

- *Computer models improving:* Computer models are required by law to be used by regulatory agencies in emissions reduction plans. Thus, the effectiveness and cost-effectiveness of emissions reduction plans depend on having accurate computer models. Improvements to meteorological simulations (using a technique called data assimilation) and emissions models (including more accurate emissions composition data) have improved computer simulations of ozone in the Uinta Basin. The models are more accurate than ever before, but more work is still needed, especially to improve emissions information.

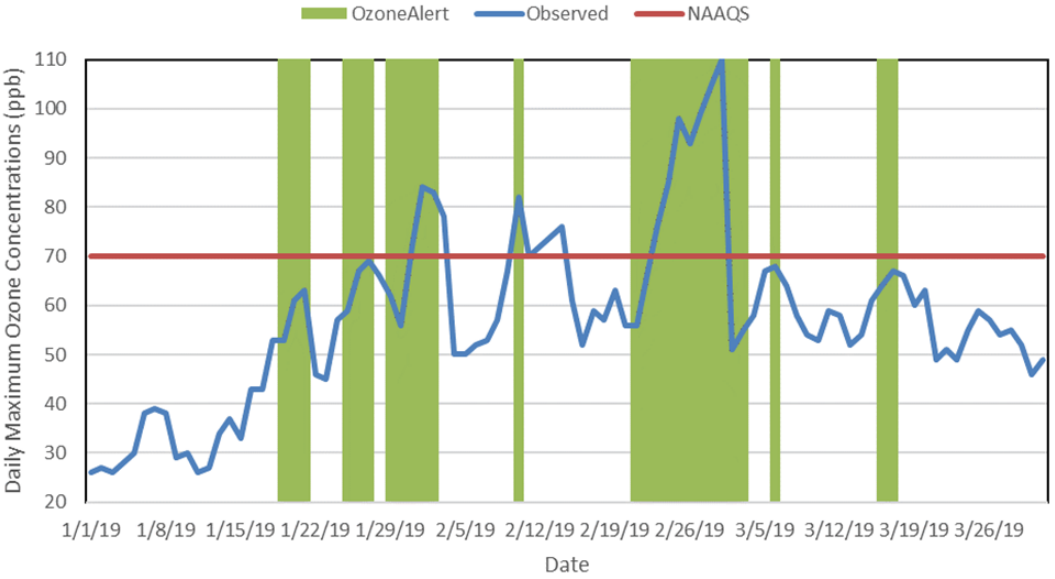


Horizontal distribution of ozone concentrations within the Uintah Basin as simulated by ONU (an older version of USU's air quality model) and G4 (a new version of the model) at 14:00 from 31 January through 2 February 2013. Coloration indicates ozone concentration. Yellow arrows show wind speed and direction. Red lines indicate terrain height of 2200 m ASL.



Comparisons of simulated 8-hour average ozone concentrations vs. observed values (OBS) at the Ouray monitoring station. SIM_OLD_OURAY indicates ozone simulated in earlier USU modeling studies, while SIM_OURAY and SIM_woPWP_OURAY indicate recent, improved simulations. The gray dashed line represents the diurnal cycle of solar elevation angle.

- *Ozone alert program:* USU issues email alerts to subscribers when high ozone is expected in the Uinta Basin. The purpose of this program is to provide the oil and gas industry with information that allows them to reduce emissions when it matters most, though any interested party is welcome to subscribe. USU issues alerts when current and forecast conditions appear conducive to the formation of high wintertime ozone and when ozone episodes are expected to end. During winter 2018-19, the program had 102 subscribers, among which 32% were from industry (mostly oil and gas producers); 21% were from regulatory agencies; 21% were private citizens; 11% were from other agencies/organizations; 11% were academic researchers; 4% were working in media, and 2% were from environmental groups.



The history of ozone alert emails that were sent out during winter 2018-19. The blue line indicates observations of daily maximum ozone at the Ouray monitoring station. Green bars indicate the duration of ozone alert periods, and the red line is the EPA ozone standard of 70 ppb.