EXECUTIVE SUMMARY

Background

The Uinta Basin is a rural area of northeastern Utah where the majority of the state's oil and gas production occurs. Ozone concentrations in excess of the current national air quality standard have been measured in the Basin during the winter. These high ozone levels are only observed in the Basin during winter inversion periods when the ground is covered by snow and stagnant, 'cold pool' conditions are present; ozone levels outside of these periods have remained below the air quality standard and conditions resulting in exceedances of the standard do not occur every year.

A multi-phased study (the Uinta Basin Winter Ozone Study, UBWOS) was initiated in the first quarter of 2012 to identify the emissions sources and the unique photochemical processes that cause elevated winter ozone concentrations, and to identify the most effective strategies to reduce winter ozone. UBWOS 2012 included measurements of ozone and ozone precursor concentrations and meteorological conditions throughout the Basin. Meteorological conditions during UBWOS 2012 were not conducive to ozone formation due to a lack of snow cover; no exceedances of the 8-hour average 75 parts per billion (ppb) National Ambient Air Quality Standard (NAAQS) were observed during UBWOS 2012. Key findings from UBWOS 2012 are described in a summary report (Final Report: 2012 Uinta Basin Winter Ozone and Air Quality Study; available at http://www.deq.utah.gov/locations/U/uintahbasin/ozone/docs/2014/03Mar/ubos_2011-12_final_report.pdf.

UBWOS 2013 took place between January and March 2013. In contrast to UBWOS 2012, conditions during UBWOS 2013 were favorable to ozone formation and numerous exceedances of the NAAQS were observed. Results from UBWOS 2013, in combination with those from UBWOS 2012, provide a wealth of information about the meteorological conditions and atmospheric chemistry associated with winter ozone episodes in the Uinta Basin. Key findings from UBWOS 2013 are described in a summary report (Final Report: 2013 Uinta Basin Winter Ozone Study; available at http://www.deq.utah.gov/locations/U/uintahbasin/ozone/strategies/studies/UBOS-2013.htm).

Results from UBWOS 2012 and UBWOS 2013 suggested that additional measurements were needed to address key remaining areas of uncertainty, foremost among which was the need to better understand the role of nitrous acid (HONO) in promoting ozone formation during the winter episodes. A more limited field campaign was undertaken during January – February 2014 to address this need. Several periods of elevated ozone associated with snow cover and strong temperature inversions were captured by the UBWOS 2014 measurements and significant additional information about the atmospheric chemical conditions during winter ozone episodes was obtained.

Findings

Key findings from UBWOS 2014 are summarized below:

Air Quality and Meteorological Conditions during UBWOS 2014

- Conditions favorable for ozone formation occurred at times during the December 2013 – March 2014 winter ozone season. Eight-hour average ozone concentrations exceeded the level of EPA's ambient air quality standard (75 ppb) at twelve out of 18 monitored locations within the Uinta Basin; Ouray experienced the most exceedance days (17).
- The most severe high ozone episodes of the winter occurred in December: the maximum 8-hour average concentration of the season (104 ppb) was recorded at Horsepool on 16 December and concentrations in excess of 75 ppb were observed at several locations within the Basin during mid and late December. Additional episodes occurred in January and early February. As in previous years, the episodes were associated with snow cover and strong inversions. Lack of snow cover precluded the occurrence of any episodes after early February.
- While ozone episodes captured by the intensive field study measurements during January and February were shorter and peak ozone concentrations were lower than episodes during the 2013 field study, conditions were nevertheless representative of typical winter ozone events.

Ozone Formation Mechanisms

- Results from UBWOS 2013 showed that the primary chemical drivers of winter ozone formation in the Uinta Basin differ greatly from summer ozone formation in urban areas but were inconclusive regarding the relative importance of HONO. Measurements made during UBWOS 2014 confirmed the unique nature of winter ozone formation mechanisms and helped clarify the role of HONO. Comparisons of five different HONO measurement techniques and HONO measurements made over a wider range of elevations within the polluted atmospheric boundary layer showed that HONO does <u>not</u> appear to be a major source of radical species driving ozone formation during the winter episodes. Instead, results from the 2014 measurements confirmed that formaldehyde and other aldehydes are the dominant radical sources. These compounds are both directly released from various emission sources and form in the atmosphere from directly emitted volatile organic compounds (VOCs) such as those emitted from oil and natural gas exploration and production activities. Aromatic VOCs (including toluene and xylene), while less abundant than other VOC species in the Basin, were also found to be particularly important sources of radicals.
- New "box model" simulations of ozone formation chemistry based on data collected at the Horsepool study site confirm earlier analyses indicating that ozone formation at this location is sensitive to VOC reductions, i.e. VOC reductions would result in ozone reductions. These results also suggest that NOx reductions, either by themselves or in conjunction with VOC reductions, would lead to ozone reductions at Horsepool. While providing an important reference point, these box model results do not take into

account spatial variations in emissions and the mixing of emissions from different sources (among other factors) and thus do not provide an assessment of the expected impact of basin-wide VOC or NOx emission reductions on ozone levels sufficiently robust to allow formulation of a comprehensive regulatory control strategy. Nevertheless, this result provides support for on-going VOC reduction measures and is an important contribution to the overall "weight of evidence" guiding control strategy design.

Results from the past three winter UBWOS field campaigns have provided valuable information for the development of improved emission inventories and model simulations of winter episodes, thereby contributing to the scientific foundations needed to develop an effective air quality management plan for the Basin:

- Several different government and university groups are continuing to develop and evaluate inventories of pollutant emissions in the Basin. Discrepancies between current emission estimates and observed pollutant concentrations have been noted and are being further investigated by these groups. The Utah Division of Air Quality is working with the Western Energy Alliance to update the inventory of emissions from oil and gas operations in the Basin. Recently enacted federal reporting and permitting regulations are also expected to generate data contributing to future improvements in the inventory. Research efforts are underway at Utah State University to better quantify emissions of formaldehyde (an important ozone precursor).

- Full scale three-dimensional computer model simulations of winter ozone episodes are under development by the Utah Division of Air Quality, EPA, BLM, University of Utah, Utah State University and NOAA. A number of areas in which model improvements are needed have been identified and work is continuing. The State of Utah has also committed $300,000 towards development of improved emissions data and models for evaluation of winter ozone control strategies.

Recommendations

UBWOS participants developed several recommendations based on the results of UBWOS 2014:

- Additional measurements are needed to compare radical sources in the western basin (where oil production dominates) with those that have been collected at Horsepool during UBWOS 2012 – 2014 (where natural gas production dominates) so as to better characterize the influence of oil production sources on ozone episodes.
- UBWOS results have shown that current emission inventories contain biases which need to be corrected. Current emission measurement and other emission inventory improvement activities are high priority and should be continued with emphasis on close collaboration between the groups involved in these efforts.
- Meteorological and air quality modeling results obtained to date are promising but additional model development and application work is needed to support emission reduction efforts.

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