Issue Paper prepared for the 2017 Western States Air Quality Modeling Workshop
DRAFT August 31, 2017

Improving Emissions Inventories and Photochemical Models for Winter O3 and PM2.5

Background

Region 10 has PM2.5 nonattainment areas in mountain valleys caused by wood stoves, while wood burning and other commercial sources of secondary organic aerosols (SOA) are important contributors to Region 8 and 9 nonattainment areas for PM2.5. Ammonium nitrate continues to be a major contributor to PM2.5 nonattainment in Regions 8 and 9. Despite an apparently sound understanding of the underlying processes, models often underpredict ammonium nitrate levels during severe wintertime episodes. Formation of nitric acid and ammonium nitrate can be NOx limited, oxidant limited or ammonia limited, and uncertainty in the models ability to adequately predict precursor levels (e.g., HNO3 and NH3) during these episodes also presents challenges for understanding if model responsiveness to precursor emission reductions is adequately captured. Understanding this responsiveness is important for current conditions as well as for determining the potential switching points for limiting precursors under scenarios with large emission reductions. Region 8 has winter ozone nonattainment areas associated with oil and gas production in rural areas, but models underestimate observed VOC concentrations in these areas. Snow cover can affect both winter PM2.5 and ozone levels both by creating stronger and more persistent cold pool inversions and by increasing production of oxidants via increased surface albedo and by heterogeneous chemistry in snow.

Problem Statement

Wood stove emissions contribute a significant fraction of winter PM2.5 during NAAQS exceedances in the Pacific Northwest. There is currently significant uncertainty in the wood stove emissions factors in AP-42. These emissions factors are largely based on highly controlled laboratory emissions tests using crib wood (dimensional lumber), not based on real world scenarios using cord wood. AP-42 emissions factors play a central role in nonattainment area attainment demonstrations. Many PM2.5 nonattainment areas dominated by wood smoke impacts are using linear emissions roll-forward modeling for their attainment demonstrations. Because crib wood based emissions factors are the only data available in most cases, they are the basis of emissions estimates in most attainment demonstrations. However, it is uncertain to what extent crib wood based emissions factors correlate with real world applications. Many attainment strategies also rely on switching fuels to cleaner burning wood products like compressed wood products, however, many of these have also not been evaluated for their emissions under real world applications. Lastly, more work is also needed to understand residential exposure to PM2.5, inside their homes, from the use of wood heating products.

Uncertainty in the models ability to represent daytime vs. nighttime pathways of ammonium nitrate formation as well as relevant processes that occur above the surface layer but contribute to surface layer concentrations is also important. Improvements in this area will likely require careful diagnostic model evaluations using comprehensive field study measurements in combination with model developments that occur across emissions, meteorology, and chemistry processes. Such evaluation and development could lead to broad improvements in the model's ability to simulate pollution processes and benefits beyond the prediction of ammonium nitrate. Previous collaborations with ORD, Utah and Wyoming researchers have led to improvements in cold pool meteorological modeling and treatment of snow albedo, but there remains uncertainty in heterogeneous snow chemistry and nighttime chemistry of oxidants and nitric acid. There is also very large uncertainty in oil and gas emissions of VOC, and continued research is needed to reconcile VOC emissions inventories estimated using "bottom-up" approaches using activity data and emissions factors versus "top-down" approaches using ambient monitoring data.

Research Topics

- Investigate the effects of snow on deposition, albedo and heterogeneous chemistry.
- Perform emissions testing of wood combustion devices.
- Perform modeling and measurement studies to address uncertainty in oil and gas emissions.
- Evaluate vertical grid resolution needed to adequately capture processes occurring in the nighttime residual and mixing in the morning.
- Evaluate the interplay between day vs. night, surface vs. aloft, and urban vs. rural processes in the formation of PM2.5.
- Prepare survey questions that will improve wood smoke emission estimates: The amount of wood burned per household and frequency of burning are often determined through telephone surveys. Questions on wood burning are often combined with other unrelated survey questions. As a result, survey period becomes too long, negatively impacting the number of participants. In addition, some questions are not as useful for estimating wood smoke emissions.
- Conduct C-14 analysis of PM filters to determine the contribution of wood burning to PM2.5: C-14 analysis of PM filters provides a ratio of new to old carbon. New carbon is from wood burning and cooking. The University of Arizona's Physics Department can perform C-14 analysis (about $550 per sample).
- Invest in satellite-based data to capture wood smoke emissions: Satellite data are used to capture emissions from wildfires, among other uses. Capturing wood smoke emissions from satellite observations is currently difficult. NASA is planning to launch a geostationary satellite in 2019 that may capture wood smoke emissions. The plan is to work closely with members of the DISCOVER-AQ program to follow new developments.

- Make winter ozonesonde measurements: ozonesonde data are available for model evaluation (global hemispheric and local) during summer, but very limited data are available for winter.

Desired Outcomes

- Identify source contributions to SOA (natural, wood burning heating, commercial etc.)
- Improve model performance for PM2.5 SIPs.
- Develop real-world wood stove emissions.
- Quantify natural SOA component of regional haze.