CRC Project A-74/E-96

Linking Tailpipe to Ambient: Phase 4

Executive Summary

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COORDINATING RESEARCH COUNCIL, INC.

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PHASE 4 FINAL REPORT EXECUTIVE SUMMARY

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This summary describes results from chemical transport model simulations of air quality in California from May 4 to June 30, 2010, which coincides with the CalNex air quality campaign. The primary purpose of the simulations was to evaluate the performance of three different organic aerosol (OA) models with each incrementally extending the treatment of OA. The first model, referred to as the 'Base' model, is the standard OA model described in CMAQ v4.7(Carlton et al. 2010), which includes a non-volatile and non-reactive treatment of primary organic aerosol and secondary organic aerosol contributions from speciated volatile organic compounds. The second model, referred to as the 'VBS' model uses the volatility basis set approach to provide semi-volatile and reactive treatment of primary organic aerosol and secondary organic aerosol contributions from intermediate volatility organic compounds and volatile organic compounds and their aging products. The focus of this work is the third model, referred to as the 'VBS-UNSP' model; it extends the VBS model to better constrain the secondary organic aerosol contributions from on- and off-road gasoline and diesel vehicles and engines using laboratory data collected during Phases 1-3 of this project (see www.crcao.org). Predictions of each model were evaluated using both routine monitoring data and data collected during the CalNex campaign.

The VBS-based models dramatically change the model predictions relative to the Base model. Although the differences in predicted absolute OA concentrations are modest (~±20%) the composition is quite different (VBS-UNSP predicts a secondary organic aerosol dominated OA while the Base model predicts primary organic aerosol dominated OA). These changes better align the model with observations. Model predictions of OA mass concentrations compared very well with filter measurements and those of OA composition compared well with high-resolution aerosol mass spectrometer measurements. Although the absolute comparisons were not perfect, diurnal patterns of predictions of OA and its sub-components showed similar trends as those measured. So while there are uncertainties in resolving certain sources (e.g., meat cooking) and pathways (e.g., aging reactions), the use of a volatility basis set framework offers a promising approach to model the emissions and atmospheric evolution of OA in both regional and global chemical transport models. These changes are similar to earlier implementations of the volatility basis set framework and are driven by the more dynamic representation of OA, including semivolatile emissions and reactive treatment of OA.

Despite the fact that the VBS-UNSP model is based on substantial new experimental data, its predictions are surprisingly similar to the VBS model. A major reason is that gasoline and diesel sources only accounted for one-quarter of the total OA in southern California. Therefore the model updates had only a limited influence on the overall OA burden. This appears to be a non-intuitive result given that gasoline and diesel sources are the most ubiquitous source of air pollution in Los Angeles region. However, strict environmental regulations have dramatically reduced pollutant emissions from motor vehicles, which has both improved air quality and increased the relative importance of other sources. Overall diesel vehicles and equipment are predicted to contribute about 3% of the organic aerosol, gasoline vehicles and equipment contribute around 22%, other anthropogenic sources (including meat cooking and solvent use) contribute about 50%, and biogenic SOA and wildfires contribute about 25%. Gasoline-fueled vehicles and equipment are predicted to contribute about seven times more organic aerosol than diesel-fueled vehicles and equipment. The difference is driven by the secondary organic aerosol production. CMU and their research team are preparing a peer-reviewed article detailing finding from this study that will be published separately.