Highlights from the Coordinating Research Council's

2018 Southern California Ozone Research Symposium

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The Coordinating Research Council (CRC) and the Truck and Engine Manufacturers Association (EMA) co-sponsored the 2018 Southern California Ozone Research Symposium (SCORES), June 6 and 7, held at the University of California, Riverside. The symposium brought together leading experts from academia, government, and industry to review and discuss the capabilities and limitations of air quality models to simulate air quality trends as observed in the past years and to predict future concentrations. After several background presentations and research updates, participants brainstormed and prioritized a list of five high-priority research-needs, summarized below, to address the knowledge gaps identified in the discussions. The discussions also acknowledged that the identified research needs from SCORES are applicable to other locations and pollutant species.

Emission controls have been leading to reductions in ozone throughout the United States. Southern California, which suffers from the worst ozone pollution in the nation, shows steady progress in ambient ozone levels (see Figures 1 and 2), yet it still requires substantial further emissions reductions (see Figure 3) to attain ozone and fine particulate matter standards. Chemical transport models play a pivotal role in assisting air regulators to develop strategies to improve air quality. Regulatory use of such models relies on relative reduction factors (RRF), which assumes models are better capable of predicting relative responses to emission changes rather than the absolute concentrations. While the RRF approach is a practical tool to predict future concentration, it does not reflect evolution of weather conditions or changes in land use due to the expansion of urban areas or climate change. In addition, uncertainties in meteorology (e.g., temperature, mixing height, vertical profiles of wind speeds), emissions inventory (e.g., magnitude of emissions, unidentified sources, temporal and spatial trends), and chemical mechanism (e.g., proper speciation, granularity of chemical speciation) limit the ability of models to simulate ambient ozone levels accurately.

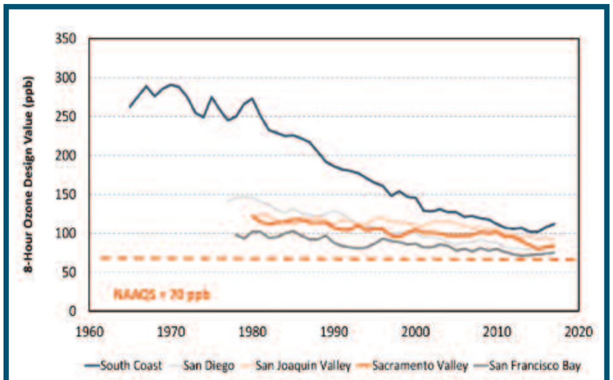

Figure 1. The 8-hr ozone design value (ppb) trend by year, from five locations in California.

Source: California Air Resources Board, Fifty-Year Air Quality Trends and Health Benefits, Slide 5; (accessed August 2, 2018).

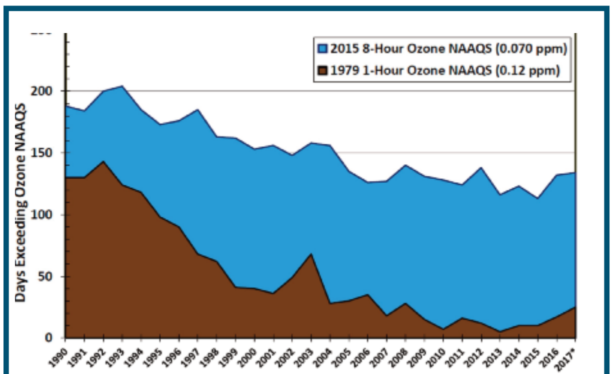

Figure 2. Number of days exceeding U.S. National Ambient Air Quality Standards (NAAQS), 1990–2017, based on preliminary 2017 data.

Source: South Coast Air Quality Management District, 2017 Ozone Season Summary and Trend Analysis, Mobile Source Committee meeting, Slide 3 (accessed August 2, 2018).

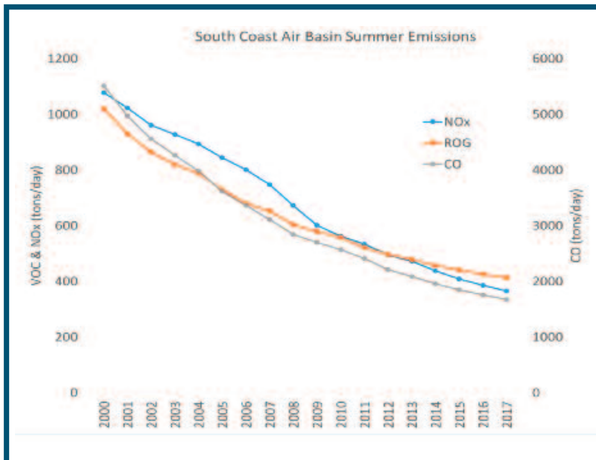

Figure 3. VOC, NOx, and CO emissions during the summer in the South Coast air basin have been steadily decreasing.

An accurate characterization of the observed trends by models is needed to further validate control strategies. High ozone episodes such as those observed in 2016 and 2017 in South Coast Air Basin underscore the year-to-year variability inherent in air quality measurements. These short-term fluctuations do not necessarily compromise longer term improvements in air quality, yet it is important to understand their causes and reflect improved science in the models. These concerns suggest further research is needed to better understand the mechanisms for ozone formation and how they are captured in the models. The resultant improvements in knowledge and models will also be beneficial to ozone and particulate matter strategies at locations beyond Southern California.

The 2018 SCORES symposium gathered together the leading experts in the relevant fields of atmospheric chemistry, ozone science, emissions inventory, and air quality modeling to discuss research needs regarding the core assumptions about the formation, mitigation, and modeling of ground-level ozone.

Eighty invited technical experts on air quality simulations attended the symposium. To help identify the most critical air quality modeling research needs that could lead to improvements in the accuracy of model outputs, the symposium began with invited presentations, followed by a series of brainstorming sessions. The presentation topics were: Ozone, Particulate Matter, and Precursor Trends in the South Coast; Modeling in the South Coast; Model Evaluation and Diagnostic Studies; Emissions and Background Ozone; Chemistry, and Physical Processes; Meteorological Inputs; and Perspectives from Other Stakeholders.

After the presentations, participants separated into three groups to brainstorm "big-picture" ideas regarding issues related to emissions inventory, chemistry, and air quality modeling. After the brainstorming session, each group convened to clarify and consolidate their ideas and voted on their group's top five priorities. The next day, the three groups developed a list of research needs based on their big-picture ideas, and voted on the top five research needs. Last, the participants reconvened to discuss the groups' priorities and voted to identify the overall top-five priority research projects. The overall top five priorities are presented below.

Top Five Overall Research Needs

Observational Response of Ozone to Changes in NOx and VOCs (Chemistry Topic)

Additional data and analyses may help further characterize the real-world relationships between oxides of nitrogen (NOx) and volatile organic compound (VOC) emissions leading to elevated ozone concentrations, and can take the form of analysis of historical data and/or additional experimental analyses. In terms of historical data analysis, appropriate research could involve developing observationally-based models linking changes in ozone and ozone sensitivities to emissions changes, both at individual locations and regionally (e.g., the regional ozone design value). Such an analysis can be compared to air quality modeling responses. An outcome of such an analysis would be to show how ozone has responded to past changes and to estimate how ozone will respond to future, planned emissions changes.

Examples of experimental approaches are projects such as in-situ, dual/triple-chamber smog chamber observations and/or experimentation at several ground sites, and aircraft measurements could be used to understand spatial (horizontal and vertical) patterns. The dual/triple chamber analyses would involve using ambient air in one chamber and adding either VOC or NOx to the other chamber(s) to follow the ozone response. Aircraft experiments and satellite observations may also provide information on the response of ozone to NOx and VOC emissions. Some aircraft data are available that could be analyzed further, such as data from the California Air Resources Board's CalNex program. New aircraft observations of precursor concentration information is needed to provide information on the current ozone air quality regime and how that may relate to future responses to emissions changes.

Short-, Medium-, and Long-Term Relationships and Evaluation of Ozone with Meteorology (Modeling Topic)

More accurate characterization of the meteorological parameters would allow scientists to better capture their influence on air quality variability over daily to decadal time-scales. Errors in meteorological fields used to drive air pollution models can influence the model's ability to accurately estimate air quality trends, thus affecting researchers' ability to make accurate inferences on plausible factors dictating discrepancies between model and observed trends.

For instance, systematic low bias in early morning surface wind speeds could artificially overestimate model NOx, which may over-attribute errors in mobile emissions. Similarly biases in temperature, radiation, ventilation, and air–surface exchange can influence biases in predicted air pollutant concentrations. These relationships must be characterized more accurately over short, medium, and long-time scales, so that more robust inferences on model-predicted changes in air quality can be made.

Mobile Source Emissions (Emissions Topic)
More research is needed to identify data gaps to accurately characterize variability in heavy-duty vehicle (HDV) emissions and how to temporally and spatially allocate these emissions. Data are needed to better understand how HDVs equipped with selective catalytic reduction deteriorate based on maintenance intervals. Satellite trend data could be used for gathering the emissions information.

Biogenic Vegetation (Emissions Topic)
Biogenic emissions contribute a significant fraction of the overall emissions inventory, and this contribution is expected to grow over time as regulatory efforts reduce anthropogenic emissions. In addition, ozone formation in most urban areas in Southern California is limited by VOC availability. However, information on urban biogenic emissions is limited, which may be critical for the ability of air quality models to characterize ozone formation in urban regions. Uncertainties in biogenic emissions stem from limited characterization of vegetation species, lack of information on the location and spatial extent of vegetated areas, or limited data on emission factors and how these are affected by stress conditions, such as exposure to high levels of air pollution, strong winds, and anomalous temperatures. Further research to improve the understanding of urban biogenic emission is necessary to accurately simulate photochemistry. Rapidly changing urban land use and adaptation of vegetation to temperature and climate changes need to be addressed appropriately as well.

Dynamical Model Evaluation in Southern California (Modeling Topic)
Chemical transport models are used to assess control effectiveness and demonstrate future attainment. Multi-decadal periods witnessing significant technological and emission changes could be analyzed to determine the trends in the ozone decline, plateau, and uptick. Trends in precursor species and other secondary pollutants should be analyzed, along with trends in background ozone and long-range transport contributions. Efforts should be devoted toward developing historical emission inventories that consistently represent the changes in emissions of various precursor species over the multi-decadal period based on changing activity data and speciation profiles reflective of control technologies and fuel formulation changes.

Conclusion

This list of prioritized research needs resulting from the 2018 SCORES symposium can serve as a guide for future funding and conducting near-term air quality research. By identifying this short list of priority research needs, the symposium participants hope to better focus limited resources toward improving the models used in air quality planning efforts. The proposed research projects would help enhance air quality modeling, and would help inform the policy decisions that utilize and rely on air quality modeling results. **em**

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In Next Month's Issue…

Air Toxics

Emissions of toxic air contaminants can result from a wide variety of industrial and commercial activities. Air toxics are those compounds that are known to cause cancer or result in other negative health effects. The January issue will evaluate the release and impact of toxic air contaminants.